Comparison of Conceptual Graphs for Modelling Knowledge of Multiple Experts : Application to Traffic Accident Analysis

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Abstract: When modelling knowledge of multiple experts, it is interesting to build a common expertise model corresponding to the kernel of knowledge common to the experts. Therefore the expertise conflicts between the expertise models of the different experts must be tackled. The domain level of an expertise model can be described through concepts linked by relations, and represented through Sowa's conceptual graph formalism.
This report presents a method for conflict management during knowledge modelling from multiple experts: this method relies on the comparison and integration of several conceptual graphs corresponding to different viewpoints, the integration being guided by different integration strategies. For the comparison of the conceptual graphs, we define and exploit possible relations that can link such graphs.
The appendix presents a base of conceptual graphs obtained by modelling the knowledge of several experts in traffic accident analysis.

Key-words: knowledge acquisition from multiple experts, conceptual graphs, knowledge modelling, conflict management, integration of expertise, traffic accident analysis.

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Comparaison de Graphes Conceptuels pour la Modélisation des Connaissances de Multiples Experts : Application à l’analyse d’accidents de la route.

Résumé : Lors de la modélisation de l’expertise de multiples experts, il est intéressant de construire un modèle d’expertise commun correspondant au noyau des connaissances communes aux experts. Aussi faut-il prendre en compte les conflits d’expertise entre les modèles d’expertise des différents experts. Le niveau domaine d’un modèle d’expertise peut être décrit grâce à des concepts reliés par des relations, et représentés à l’aide du formalisme des graphes conceptuels de Sowa.
Ce rapport présente une méthode pour la gestion de conflits lors de la modélisation de l’expertise de multiples experts : cette méthode repose sur la comparaison et l’intégration de multiples graphes conceptuels correspondant à différents points de vue, l’intégration étant guidée par différentes stratégies d’intégration. Pour la comparaison entre les graphes, nous définissons et exploitons différentes relations possibles pouvant relier de tels graphes.
L’annexe décrit une base de graphes conceptuels obtenue en modélisant les connaissances de plusieurs experts en analyse des accidents de la route.

Mots-clé : acquisition des connaissances de multiples experts, graphes conceptuels, modélisation des connaissances, gestion de conflits, intégration d’expertises, accidentologie.

(Abstract: pto)

TABLE DES MATIERES

1 Introduction*

Expertise capitalization in a company or development of a knowledge-based system may involve several experts whose knowledge is acquired. These experts can stem from the same domain or from different ones. When knowledge is acquired from several experts, the knowledge engineer(s) must detect and solve several kinds of conflicts: (a) differences of terminology, (b) incompatibility between terminologies, (c) differences between compatible reasonings (i.e. the experts use different problem solving methods but obtain non contradictory results), (d) incompatibility of reasonings (i.e. the different problem solving methods used by the experts lead to contradictory results). Very few knowledge acquisition methods take into account expertise conflict management (study of terminology conflicts in (Shaw and Gaines (1989); Gaines and Shaw (1989)); management of several viewpoints in Easterbrook (1991); conflict detection in the framework of KADS-I methodology in Dieng (1995).

After the knowledge engineer elicited rough data from the different experts, he must analyze the elicited data in order to build: a) a *common model* corresponding to the kernel of knowledge common to all experts and perhaps models common only to sub-groups of experts, b) *specific models* corresponding to knowledge specific to an expert and not shared by other experts. Two approaches are possible: (1) either the knowledge engineer tries to build such models (the common one and the specific ones) directly from the rough data, or (2) he builds separately each model of expertise corresponding to each expert (independently of the others) and then tries to compare the obtained models of expertise in order to find their common parts and their specific parts. In this second case, the common and specific models are obtained not directly from the rough data but from the separate expertise models. Moreover, when several knowledge engineers can be involved, the construction of the expertise models is more complex: a knowledge engineer may be responsible for modelling one expert, or for modelling a specific aspect throughout the different experts.

* This paper is a more detailed version of a paper published at ISMIS’96 (Dieng, 1996).

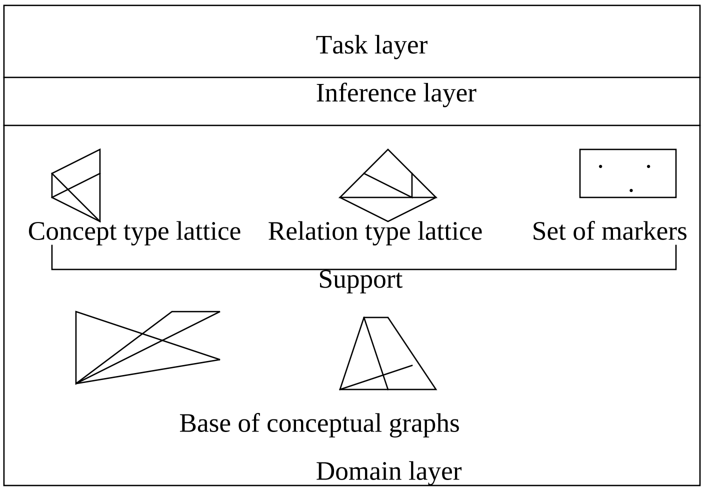


Figure 1: Expertise model of an agent.

In our knowledge acquisition tool Katemes, we represent each expert by an artificial agent (Dieng et al (1994b)). Our model of agent indicates *individual features* (concerning the agent itself independently of the organization in which it is inserted and independently of the other agents) and *social features* related to the agent's insertion in an organization and to its interactions with the other agents. Such features must then be instantiated by the knowledge engineer for the considered application, thanks to knowledge acquisition process. A significant individual aspect is the expertise model of the agent. This expertise model is described using the Kads framework (Wielinga et al, 1992) with three layers: domain, inference and task. Moreover, we chose to represent the concepts and relations of the domain layer through knowledge graphs. In (Dieng et al (1994a), Dieng(1995)), we had proposed techniques for comparing knowledge graphs representing multiple experts. In this paper, we will adapt such techniques to Sowa's conceptual graph formalism (Sowa, 1984, 1992, 1993), so as to offer a conflict management mechanism based on the comparison and integration of multiple conceptual graphs representing knowledge of multiple experts. As shown in Figure 1, an agent has a *support* (made of a concept type lattice, a relation type lattice, and a set of markers satisfying a conformity relation w.r.t. the concept type lattice) and a *base of canonical conceptual graphs*, built on this support and representing the view of this agent on the world and its expertise. Therefore, the detection of conflicts among several expertises relies on the comparison of the domain layers of the expertise models of the agents associated to the experts, such domain layers being represented by conceptual graphs.

After a brief summary of the model of conceptual graph formalism, we will present our algorithm of comparison, that tries to build a common support and then to determine the relations between elementary parts of the conceptual graphs to be compared and between the conceptual graphs themselves. Then we will present possible integration strategies that may guide the construction of the integrated graph. In conclusion, after a comparison with related work, we will evoke possible extensions of our work. The appendix will present several examples extracted from the bases of conceptual graphs obtained by modelling of knowledge of several experts in road accident analysis.

2 Conceptual Graphs

2.1 Conceptual Graph Model

We rely on the model of simple conceptual graphs, as defined in (Sowa (1984, 1992, 1993); Chein and Mugnier (1992); Willems (1995)). A support S is a tuple = ($\mathcal{T}$c, $\mathcal{T}$r, $\mathcal{B}$, $\mathcal{M}$, conf) where :

- $\mathcal{T}$c is a lattice of concept types (the ordering relation on $\mathcal{T}$c is denoted $\leq$). $\mathcal{T}$c admits a maximal type (called universal type, and denoted T) and a minimal type (called absurd type, and denoted $\perp$). Two elements t_1 and t_2 of $\mathcal{T}$c have a maximal common subtype (denoted $t_1 \cap t_2$) and a minimal common supertype (denoted $t_1 \cup t_2$).

- $\mathcal{T}$r is generally a partially ordered set of relation types. Moreover, we will suppose that $\mathcal{T}$r has also a structure of lattice: the ordering relation on $\mathcal{T}$r is denoted $\leq$, the universal relation type is denoted Relation and the absurd relation type is denoted Absurd-relation. The maximal common subtype of two elements rel_1 and rel_2 of $\mathcal{T}$r is denoted $rel_1 \cap rel_2$ and their minimal common supertype $rel_1 \cup rel_2$.

- $\mathcal{B}$ is a set of "star graphs" in bijection with $\mathcal{T}$r, and indicating the signature of each relation type (i.e. its arity and the maximal concept type of each of the concept-nodes neighbours of such a relation).

- M is a set of individual markers.

- conf is a conformity relation, that relates type labels to individual markers.

A conceptual graph defined with respect to a support S is a connected, bipartite, labelled graph, ($\mathcal{C}$, $\mathcal{R}$, $\mathcal{E}$, *label*) with labeled vertices (the labelling respecting some constraints).

- $\mathcal{C}$ is the set of concept nodes (or C-vertices),

- $\mathcal{R}$ is the set of relation nodes (or R-vertices),

- $\mathcal{E}$ is the set of edges,

- *label* is a function of $\mathcal{C} \cup \mathcal{R} \cup \mathcal{E}$ that associates to a C-vertex or R-vertex or an edge its label.

In the remaining sections of the paper, we will exploit the following characteristics:

- We will exploit the function neighbour : N * $\mathcal{R} \rightarrow \mathcal{C}$: rel being a R-vertex of arity n and i being an integer $\in$ N, neighbour (i, rel) is the ith C-vertex adjacent to the R-vertex rel if i $\leq$ n and () otherwise.

- To a given conceptual graph, we will associate $\mathcal{A}$ the set of its "elementary links" denoted rel (C_1, ..., C_n), with rel $\in \mathcal{R}$, with arity(rel) = n, and for i $\in$ [1..n], C_i = neighbour (i, rel) $\in \mathcal{C}$. Therefore, we will rather consider a conceptual graph as a tuple ($\mathcal{C}$, $\mathcal{R}$, $\mathcal{A}$, $\mathcal{E}$, *label*) and we will rather use the simplified notation CG = ($\mathcal{C}$, $\mathcal{R}$, $\mathcal{A}$) .

- We make some simplifying hypotheses:
  $\forall$ rel_1 and $rel_2 \in \mathcal{T}r$ \ {Relation, Absurd-relation} such that $rel_1 < rel_2$, we have:
  arity (rel_1) = arity (rel_2) and type (neighbour (i, B (rel_1))) $\leq$ type (neighbour (i, B (rel_2))).

- To each concept type, the function Names associates a set composed of its main name and of its synonyms.

2.2 Operations on Conceptual Graphs

The following operations on conceptual graphs are defined in Sowa (1984) and in Chein and Mugnier (1992): copy of a conceptual graph, basic operations of specialization (simplication by suppression of twin R-vertices, restriction on the labels of R-vertices or of C-vertices, elementary join on two C-vertices having the same label), basic operations of generalization (addition of a twin R-vertex, extension, elementary split), projection of a conceptual graph on another conceptual graph, extended join and maximal join of two conceptual graphs.

In this paper, we will use the following vocabulary:

- "concept specialization" or restriction of a concept type: on a concept-node [type:ref], type is replaced by one of its subtypes,

- "instantiation" or restriction of a referent : on a concept-node [type:*ref], the generic marker *ref is replaced by an individual marker conform with type,

- "relation specialization" or restriction of a relation type : on a R-vertex denoted (type-rel) , type-rel is replaced by one of its subtypes,

- "concept generalization" or extension of a type : on a concept-node [type:ref], type is replaced by a supertype,

- "conceptualization" or extension of a referent : on a concept-node [type:ind-ref], the individual marker ind-ref is replaced by a generic marker conform with type,

- "relation generalization" or extension of a relation type : on a R-vertex (type-rel) , type-rel is replaced by a supertype of type-rel.

Last, an operator Φ allows to associate a first logics formula Φ (CG) to a conceptual graph CG (Sowa, 1984; Chein and Mugnier, 1992). Our purpose is to exploit all such operations in order to compare and integrate conceptual graphs stemming from different experts: we will emphasize particular cases of projection of a CG into another.

3 Exploitation of Conceptual Graphs for Multi-expertise

3.1 Modelling Domain Models through Conceptual Graphs

During the knowledge modelling phase, the knowledge engineer needs to model the concepts handled by the experts. For each expert, the concept types handled by this expert will be described through the concept type lattice associated to the agent representing this expert. To each relation type, a list of incompatible relation types is associated: in a conceptual graph defined on the considered support, the concepts C_1, ..., C_n cannot be linked by two incompatible relations. We also distinguish :

- *generic graphs*, where all the concepts will be generic (i.e. their referents are generic markers, that may be named or not),
- *specific graphs*, where all the concepts are specific (i.e. their referents are individual markers),
- and *hybrid graphs* that include both generic concepts and individual ones.

In a given application, some *viewpoints* can be stressed: for example, *subpart-viewpoint*, *electrical-viewpoint*, *mechanical-viewpoint*, *influence-viewpoint*. The base of canonical conceptual graphs associated to an agent can then be partitioned according to such viewpoints. So, in a given application on the building of a house, the expert in electricity may have associated a conceptual graph corresponding to the *electrical* viewpoint on the domain, while the specialist in mechanics may use a conceptual graph corresponding to the *mechanical* viewpoint, and the architect may handle both kinds of conceptual graphs. In an application of traffic accident analysis, in addition to a *task* viewpoint, the experts handle conceptual graphs focusing on the *drivers* (with a structural model viewpoint and a cognitive model viewpoint), the *vehicles* (with a structural model viewpoint and a causal model viewpoint), the *infrastructure* (with a structural model viewpoint and a causal model viewpoint), the *interaction driver-vehicle*, the *interaction driver-infrastructure* and the *interaction vehicle-infrastructure*.

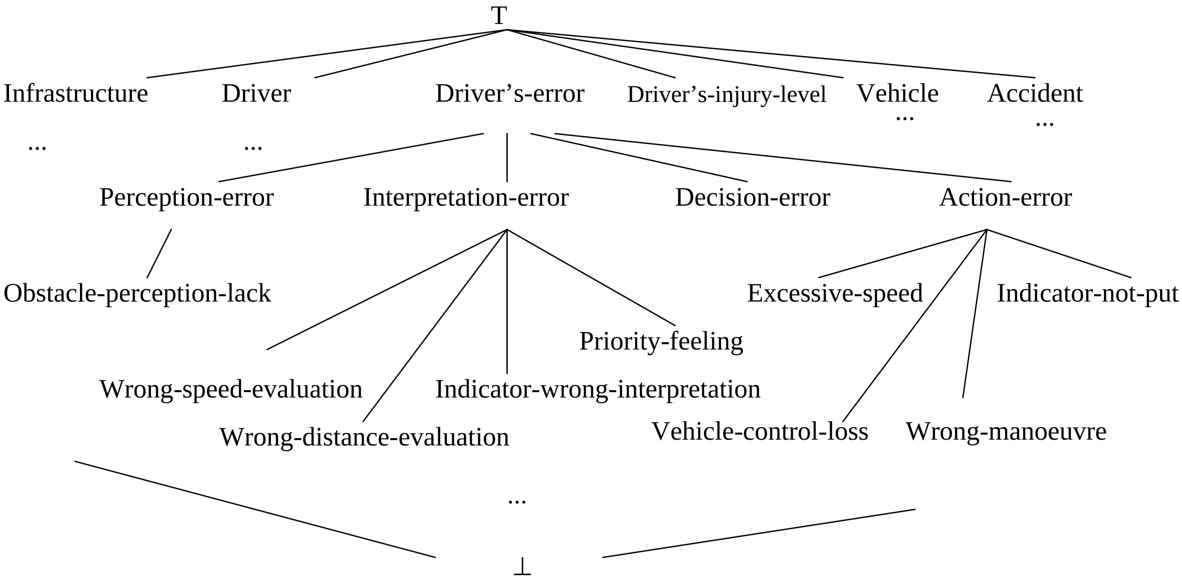


Figure 2: Hierarchy of driver's errors in the concept type lattice in accidentology

Let us consider several experts whose knowledge was modelled separetely. To each expert corresponds an artificial agent, to which are associated:

- a *support* (i.e. a concept type lattice, a relation type hierarchy, a set of markers and the conformity relation),
- a *base of canonical conceptual graphs* corresponding to different viewpoints : for sake of simplicity, we will suppose that in each agent, there is at most one CG corresponding to a given viewpoint. Each canonical conceptual graph is considered as true (the logical formula associated to one CG of the base is true).

Figure 2 shows an example of concept type lattice and figure 3 an example of relation type lattice.

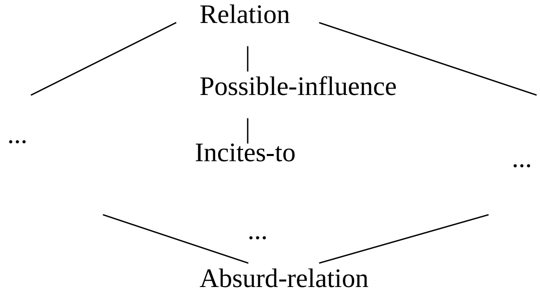


Figure 3: Example of relation type lattice in accidentology

3.2 Algorithm of Integration of two Expertise Models

The algorithm of comparison of the expertise models of two agents is based on the following steps:

1) Comparison of the two supports.

2) Comparison of the two bases of conceptual graphs : for each viewpoint for which both agents have associated conceptual graphs, compare the two corresponding conceptual graphs, CG_1 and CG_2. This comparison of conceptual graphs of the same viewpoint can be decomposed as follows:

- Preprocessing: In each conceptual graph of an agent, replace the expert's terms by the agreed terms adopted in the common lattices of concept types and of relation types. To each concept type son of universal type in the common support, associate the C-vertices of CG_1 and CG_2, compatible with this concept type.

- Establish the relations between "elementary links" of both CG : rel_1 (C_{11},...,C_{1n}) and rel_2 (C_{21},...,C_{2n}).

- Establish the relations between CG_1 and CG_2.

3) Construction of the base of integrated CG, according to the chosen integration strategy: by exploiting the relations previously established, build the integrated CGs for each viewpoint.

The next sections will detail the different steps of the algorithm.

3.3 Comparison of two Supports

Searching the common support associated to several experts of the same domain can be seen as a part of the search of a common ontology or of a shared ontology among the experts. One can work either at the knowledge level (Newell, 1984), without choosing a representation formalism or at the symbol level, once chosen a representation formalism. Our choice of the framework of the conceptual graph formalism allows us to propose algorithms based on the notions underlying conceptual graphs. Of course, we don't hope to automate all the steps necessary for building such a common support from multiple experts : clearly, this construction must involve the experts in order to solve some conflicts, in particular in the case of experts of different domains.

Our purpose is to compare the conceptual graphs of the same viewpoint of two agents, in order to detect and solve potential conflicts among them. For example, the *electrical viewpoint conceptual graphs* of two agents can be compared but the comparison between an *electrical viewpoint conceptual graph* and a *mechanical viewpoint conceptual graph* is meaningless.

Two approaches are possible for modelling two different experts:

- First approach: build the supports associated to each expert, build the common support on which both experts agree, build the conceptual graphs of the experts on this common support, compare the conceptual graph of an expert corresponding to a viewpoint with the conceptual graph of the other expert corresponding to the same viewpoint.
- Second approach: build the supports associated to each expert, for each expert, build his conceptual graphs on his own support, compare the supports of both experts so as to build the common support on which both experts agree, compare the two conceptual graphs corresponding to the same viewpoint.

3.3.1 Construction of the Common Support

For building the common support from both supports of the experts:

1. *Compare the concept type lattices* of the two experts: try to solve the name conflicts (i.e recognize synonyms and homonyms among the concept type names), try to compare the definitions (Necessary and Sufficient Conditions) associated to a given concept type in both supports and try to join the subtypes of a given concept type. If necessary, some new concept types may be added and the names of some concept types may be changed. After that, a “common concept type lattice”, corresponding to the integration of both lattices of concept types, is obtained. With each concept type appearing in this integrated lattice, the different names used by the different specialists must be stored.

   An automated matching of two concept types of two agents is complex. Generally, when the experts stem from the same domain, they often use the same term for the same concept, which is not the case for experts of different domains. A sophisticated matching procedure should be able to compare: two atomic concept types (at least by their names), an atomic concept type and a concept type definition (i.e. its necessary and sufficient conditions), two concept type definitions, the "neighbouring" of two concept types, the schemas (or necessary conditions) associated to two concept types.

   At present, we restrict ourselves to criteria to match two concept types according to their names. We can choose the following criterion : we suppose that if two concept types C_1 and C_2 have the same main name , there is little chance that there exists among the synonyms of C_1 a homonym of a synonym of C_2. Therefore we can consider that C_1 and C_2 can be identified iff cardinal $(\text{Names}(C_1) \cap \text{Names}(C_2))$ is greater to a given threshold.

   Another solution would be to introduce a notion of neighbouring of a concept. This neighbouring may be constituted by the father(s), the sons, the brothers and the names associated to a concept. So, if two concepts have the same main name, several common synonyms, a common father and several common sons, they should be considered as identical.

2. *Compare the relation type lattices* used by the two experts: try to solve the name conflicts, the conflicts among the signatures of the relations, and try to join the subtypes of a given relation type.

If needs be, some new types may be added and the names of some types may be changed. Then, the "common relation type hierarchy" obtained correspond to the integration of the two hierarchies of relations. With each relation appearing in this common hierarchy, the different names adopted by the different specialists must be stored. Build $\mathcal{B}_{com}$, containing the adapted graphs indicating the signature of the common relations.

3. *Compare the two sets of markers.* If an individual marker appears in both supports and satisfies the two conformity relations, it can be considered as representing the same individual. An automated matching of the generic referents seems rather complex: therefore, we will suppose that the experts agree on the names of the generic referents. Then, the common conformity relation $conf_{com}$ can be built.

3.4 Comparison of Conceptual Graphs

Once obtained the common support ($\mathcal{T}_{c\text{-}com}$, $\mathcal{T}_{r\text{-}com}$, $\mathcal{B}_{com}$, $\mathcal{M}_{com}$, $conf_{com}$), the algorithm of comparison proceeds as follows:

1. In each conceptual graph of an expert, replace the expert's terms by the agreed terms adopted in the common lattices of concept types and of relation types.
2. *For each viewpoint* v (such as "subpart viewpoint", "electrical viewpoint", "influence viewpoint", etc) *for which both experts have associated conceptual graphs, compare the two corresponding conceptual graphs*, CG_1 = CG (Agent$_1$, v) and CG_2 = CG (Agent$_2$, v):

- For each concept type, son of the universal type in the common concept type lattice $\mathcal{T}_{c\text{-}com}$ (resp. the common relation type lattice $\mathcal{T}_{r\text{-}com}$), a preprocessing on CG_1 and CG_2 helps to gather the C-vertices (resp. R-vertices) that belong to this type and that can be compared to each other later. For example, to the concept type *Driver's-error*, C-vertices such as [Driver's error], [Excessive-speed : *x], [Vehicle-control-loss : *y], etc, can be associated.
  For each viewpoint v
    for each agent Agent$_i$, let CG_i = CG (Agent$_i$, v) :
      a) for each root $\in$ sons (T, $\mathcal{T}_{c\text{-}com}$),
        store-comparable-concepts (CG_i, root) $\rightarrow$ Lconcepts (CG_i,root)
      b) for each root-rel $\in$ sons (T, $\mathcal{T}_{r\text{-}com}$) ,
        store-comparable-relations(CG_i, root-rel) $\rightarrow$ Lrelations (CG_i,root-rel)
      We recall that all the comparable relations have the same arity.

- Establish relations between "elementary links":
  for each root-rel $\in$ sons (T, $\mathcal{T}_{r\text{-}com}$)
    for each rel$_1$ $\in$ Lrelations (CG_1, root-rel) ,

for each $rel_2 \in$ Lrelations (CG_2,root-rel) ,
let n be the common arity of rel_1, rel_2, root-rel,
if for each $i \in [1..n]$ are-comparable-concepts (neighbour (i, rel_1), neighbour (i, rel_2))
(i.e. the ith neighbour of rel_1 and the ith neighbour of rel_2 have a common supertype different from the universal type),
then find-elementary-links (rel_1 , CG_1) $\rightarrow$ Llinks (rel_1,CG_1)
find-elementary-links (rel_2 , CG_2) $\rightarrow$ Llinks (rel_2,CG_2)
store-relations-on-relations (rel_1,rel_2) $\rightarrow$ Lrelations (rel_1,rel_2).

Section 3.6, page 17 will define more precisely all these relations that can relate such elementary links.

- Establish relations between CG_1 and CG_2.
  Search whether CG_2 is a subgraph (resp. supergraph) of CG_1, a contraction (resp. an expansion) of CG_1, a total or partial generalization (resp. specialization), a total or partial instantiation (resp. conceptualization) of CG_1.
  Section 3.7, page 20 will define more precisely all these relations that can link two conceptual graphs.

3. Build the integrated graph according to the chosen integration strategy integrated-CG (CG_1, CG_2, strat).
   Section 3.8.1, page 23 will define more precisely the possible integration strategies that can guide this integration of conceptual graphs.

3.5 Relations among C-vertices of Different Conceptual Graphs

3.5.1 Definitions

Let $CG_1 = (\mathcal{C}_1, \mathcal{R}_1, \mathcal{A}_1)$ and $CG_2 = (\mathcal{C}_2, \mathcal{R}_2, \mathcal{A}_2)$ the conceptual graphs to be compared, Ref_1 and Ref_2 the respective sets of the referents of the C-vertices appearing in CG_1 and CG_2, and let $Ref_{tot} = Ref_1 \cup Ref_2$. A partial relation can be defined on Ref_{tot} : $ref_i < ref_j$ iff ref_i is an individual marker and ref_j a generic one.

In this section, we suppose that the common support has been built and that the updating of the referents have been made. Let C_1 a C-vertex in CG_1 and C_2 a C-vertex in CG_2. We define the following binary relations on $\mathcal{C}_1 * \mathcal{C}_2$:

- *is-same-concept* (C_1 , C_2) iff type (C_1) = type (C_2) $\wedge$ referent (C_1) = referent (C_2),
- *is-ascendant-concept* (C_1 , C_2) iff type (C_2) < type (C_1) $\wedge$ referent (C_1) = referent (C_2),

is-descendant-concept (C_1, C_2) iff is-ascendant-concept (C_2, C_1) ,

- *is-generic-concept* (C_1, C_2) iff type (C_1) = type $(C_2) \wedge$ referent $(C_2) <$ referent (C_1) ,
  is-specific-concept (C_1, C_2) iff is-generic-concept (C_1, C_2) ,

- *is-ascendant-generic-concept* (C_1, C_2) iff type $(C_2) <$ type $(C_1) \wedge$ referent $(C_2) <$ referent (C_1),
  is-descendant-specific-concept (C_1, C_2) iff is-ascendant-generic-concept (C_2, C_1),

- *is-more-general-concept* (C_1, C_2) iff is-ascendant-concept $(C_1, C_2) \vee$ ascendant-generic-concept (C_1, C_2),
  is-more-specific-concept (C_1, C_2) iff is-more-general-concept (C_2, C_1),

- *are-comparable-concepts* (C_1, C_2) iff type $(C_1) \cup$ type $(C_2) \neq T$,

- *possible-specialization* (C_1, C_2) iff type $(C_1) \cap$ type $(C_2) \neq \perp$.

We also define the following functions: $\mathcal{C}_1 * \mathcal{C}_2 \rightarrow \mathcal{C}_{com}$:

- *most-general* (C_1, C_2) = C_1 if is-same-concept $(C_1, C_2) \vee$ is-more-general-concept (C_1, C_2),
  C_2 if is-more-general-concept (C_2, C_1),
  () otherwise.

- *common-generalization* (C_1, C_2) = [type : ref]
  with type = type $(C_1) \cup$ type (C_2)
  and ref = referent (C_1) if referent $(C_2) <$ referent (C_1),
  referent (C_2) if referent $(C_1) <$ referent (C_2),
  a new generic referent conform with type, otherwise.

- *most-specific* (C_1, C_2) = C_1 if is-same-concept $(C_1, C_2) \vee$ is-more-specific-concept (C_1, C_2),
  C_2 if is-more-specific-concept (C_2, C_1),
  () otherwise.

- *common-specialization* (C_1, C_2) = [type : ref]
  with type = type $(C_1) \cap$ type (C_2)
  and ref = referent (C_1) if referent $(C_1) <$ referent (C_2) ,
  referent (C_2) if referent $(C_2) <$ referent (C_1),
  () otherwise.

- *most-generic* (C_1, C_2) = C_1 if is-same-concept $(C_1, C_2) \vee$ is-generic-concept (C_1, C_2),
  C_2 if is-generic-concept (C_2, C_1),

() otherwise.

- *common-conceptualization* (C_1 , C_2) = [type : ref]
  with type = type (C_1) = type (C_2)
  and ref = referent (C_1) if referent (C_2) < referent (C_1),
  referent (C_2) if referent (C_1) < referent (C_2) ,
  a new generic referent conform with type, otherwise.

- *most-instantiated* (C_1, C_2) = C_1 if is-same-concept (C_1, C_2) $\vee$ is-specific-concept (C_1, C_2),
  C_2 if is-specific-concept (C_2, C_1),
  () otherwise.

- *common-instantiation* (C_1, C_2) = [type : ref]
  with type = type (C_1) = type (C_2)
  and ref = referent (C_1) if referent (C_1) < referent (C_2) ,
  referent (C_2) if referent (C_2) < referent (C_1),
  () otherwise.

3.5.2 Examples

is-same-concept ([Driver’s-error : *x], [Driver’s-error : *x])

is-ascendant-concept ([Driver’s-error : err-Paul], [Wrong-distance-evaluation : err-Paul])

is-descendant-concept ([Wrong-distance-evaluation : err-Paul], [Driver’s-error : err-Paul])

is-generic-concept ([Vehicle-control-loss : *x], [Vehicle-control-loss : err-Jean])

is-specific-concept ([Vehicle-control-loss : err-Jean], [Vehicle-control-loss : *x])

is-ascendant-generic-concept ([Driver’s-error : *y], [Wrong-manoeuvre : err-Fred])

is-descendant-specific-concept ([Wrong-manoeuvre : err-Fred], [Driver’s-error : *y])

is-more-general-concept ([Driver’s-error : *y], [Vehicle-control-loss : err-Jean])

is-more-specific-concept ([Vehicle-control-loss : err-Jean], [Driver’s-error : *y])

are-comparable-concepts ([Obstacle-perception-lack : *x], [Indicator-not-put : *y])

most-general ([Driver’s-error : *y], [Vehicle-control-loss : err-Jean]) = [Driver’s-error : *y]

common-generalization ([Vehicle-control-loss : err-Jean], [Wrong-manoeuvre : err-Fred]) = [Action-error : *z]

most-specific ([Driver’s-error : *y], [Vehicle-control-loss : err-Jean]) = [Vehicle-control-loss : err-Jean]

common-specialization ([Driver’s-error : *y], [Vehicle-control-loss : err-Jean]) = [Vehicle-control-loss : err-Jean] most-instantiated ([Wrong-manoeuvre : err-Fred], [Wrong-manoeuvre : *y]) = [Wrong-manoeuvre : err-Fred]

common-instantiation ([Wrong-manoeuvre : err-Fred], [Wrong-manoeuvre : *y]) = [Wrong-manoeuvre : err-Fred]

3.6 Relations among Elementary Links of Conceptual Graphs

3.6.1 Definitions

Upon an elementary link of a conceptual graph rel (C_1 , ..., C_n), the following operations are possible: "concept specialization (resp. generalization)" on C_i , "instantiation (resp. conceptualization)" on C_i , "relation specialization (resp. generalization)" on rel.

The kinds of relations possible between elementary links of CG_1 and CG_2 , respectively denoted $link_1 = rel_1(C_{11} ... C_{1n})$ and $link_2 = rel_2 (C_{21} ... C_{2n})$ - where rel_1 and rel_2 have the same arity n - are the following :

* *is-same-link* ($link_2$, $link_1$) iff
$type(rel_1) = type(rel_2) \wedge \forall i \in [1, n]$, is-same-concept (neighbour (i, rel_2), neighbour (i, rel_1))

* *are-incompatible-links* ($link_2$, $link_1$) iff
incompatible ($type(rel_1)$, $type(rel_2)$) $\wedge \forall i \in [1, n]$, is-same-concept (neighbour (i, rel_2), neighbour (i, rel_1))

* *is-relation-specialization* ($link_2$, $link_1$) iff
$type(rel_2) < type(rel_1) \wedge \forall i \in [1, n]$, is-same-concept (neighbour (i, rel_2), neighbour (i, rel_1))

* *is-relation-generalization* ($link_2$, $link_1$) iff
is-relation-specialization ($link_1$, $link_2$)

* *is-concept-total-specialization* ($link_2$, $link_1$) iff
$type(rel_1) = type(rel_2) \wedge \forall i \in [1, n]$, is-descendant-concept (neighbour (i, rel_2), neighbour (i, rel_1))

* *is-concept-total-generalization* ($link_2$, $link_1$) iff
is-concept-total-specialization ($link_1$, $link_2$)

* *is-total-instantiation* ($link_2$, $link_1$) iff
$type(rel_1) = type(rel_2)$
$\wedge \forall i \in [1, n]$, type (neighbour ($i$, rel_1) = type (neighbour (i, rel_2))

$\wedge$ referent (neighbour (i, rel_2) < referent (neighbour (i, rel_1)))

* *is-total-conceptualization* ($link_2$, $link_1$) iff
is-total-instantiation ($link_1$, $link_2$)

* *is-concept-partial-specialization* ($link_2$, $link_1$) iff
type(rel_1) = type (rel_2)
$\wedge$ $\forall$ i $\in$ [1, n], (is-descendant-concept (neighbour (i, rel_2), neighbour (i, rel_1))
$\vee$ is-same-concept (neighbour (i, rel_1), neighbour (i, rel_2)))
$\wedge$ $\exists$ i $\in$ [1, n], is-descendant-concept (neighbour (i, rel_2), neighbour (i, rel_1))

* *is-concept-partial-generalization* ($link_2$, $link_1$) iff
is-concept-partial-specialization ($link_1$, $link_2$)

* *is-partial-instantiation* ($link_2$, $link_1$) iff
type(rel_1) = type (rel_2)
$\wedge$ $\forall$ i $\in$ [1, n], (is-specific-concept (neighbour (i, rel_2), neighbour (i, rel_1))
$\vee$ is-same-concept (neighbour (i, rel_1), neighbour (i, rel_2)))
$\wedge$ $\exists$ i $\in$ [1, n], is-specific-concept (neighbour (i, rel_2), neighbour (i, rel_1))

* *is-partial-conceptualization* ($link_2$, $link_1$) iff
is-partial-instantiation ($link_1$, $link_2$)

* *is-relation&concept-total-specialization* ($link_2$, $link_1$) iff
type(rel_2) < type (rel_1) $\wedge$ $\forall$ i $\in$ [1, n], is-descendant-concept (neighbour (i, rel_1), neighbour (i, rel_2))

* *is-relation&concept-total-generalization* ($link_2$, $link_1$) iff
is-relation-&concept-total-specialization ($link_1$, $link_2$)

* *is-relation-specialization&total-instantiation* ($link_2$, $link_1$) iff
type(rel_2) < type (rel_1)
$\wedge$ $\forall$ i $\in$ [1, n], is-specific-concept (neighbour (i, rel_2), neighbour (i, rel_1))

* *is-relation-generalization&total-conceptualization* ($link_2$, $link_1$) iff
is-relation-specialization&total-instantiation ($link_1$, $link_2$)

* *is-relation&concept-partial-specialization* ($link_2$, $link_1$) iff
type(rel_2) < type (rel_1)
$\wedge$ $\forall$ i $\in$ [1, n], is-descendant-concept (neighbour (i, rel_2), neighbour (i, rel_1))

$\vee$ is-same-concept (neighbour (i, rel_1), neighbour (i, rel_2))

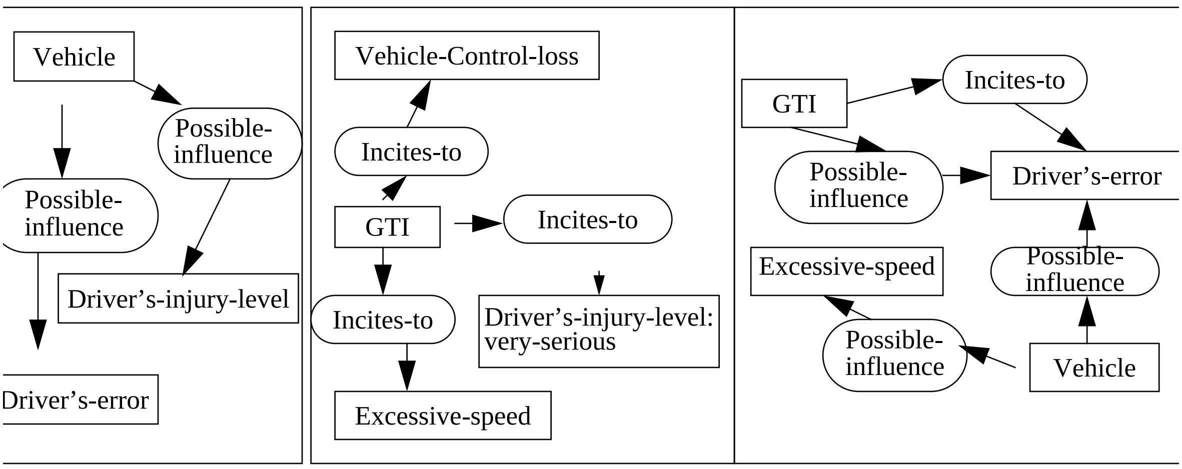
* *is-relation&concept-partial-generalization* ($link_2$, $link_1$) iff
is-relation&concept-partial-specialization ($link_1$, $link_2$)

* *is-relation-specialization&partial-instantiation* ($link_2$, $link_1$) iff
type(rel_2) < type (rel_1)
$\wedge$ $\forall$ i $\in$ [1, n],(is-specific-concept (neighbour (i, rel_2), neighbour (i, rel_1))
$\vee$ is-same-concept (neighbour (i, rel_1), neighbour (i, rel_2)))
$\wedge$ $\exists$ i $\in$ [1, n], is-specific-concept (neighbour (i, rel_2), neighbour (i, rel_1))

* *is-relation-generalization&partial-conceptualization* ($link_2$, $link_1$) iff
is-relation-specialization&partial-instantiation ($link_1$, $link_2$)

3.6.2 Examples

For binary relations, the elementary link : $C_{in} \overset{1}{—} (rel) \overset{2}{—} C_{out}$ will be denoted $C_{in} \rightarrow (rel) \rightarrow C_{out}$



CG_1 CG_2 CG_3
Viewpoint interaction-vehicle-driver

Figure 4 : Conceptual graphs of three experts, on the viewpoint interaction-vehicle-driver

Figure 4 shows an example in accidentology.
In CG_1, let us note $Link_1$ = [Vehicle] $\rightarrow$ (Possible-influence) $\rightarrow$ [Driver's-error]

$Link_2$ = [Vehicle] → (Possible-influence) → [Driver's-injury-level]
In CG_2, let us denote :
$Link_3$ = [GTI] → (Incites-to) → [Excessive-speed],
$Link_4$ = [GTI] → (Incites-to) → [Vehicle-control-loss],
$Link_5$ = [GTI] → (Incites-to) → [Driver's-injury-level: very-serious],
In CG_3, let us denote :
$Link_6$ = [GTI] → (Possible-influence) → [Driver's error],
$Link_7$ = [GTI] → (Incites-to) → [Driver's-error],
$Link_8$ = [Vehicle] → (Possible-influence) → [Excessive-speed],
$Link_9$ = [Vehicle] → (Possible-influence) → [Driver's-error],
Let us notice that CG_3 is not put on a canonical form: all the possible internal joins upon it have not been performed.

We have the following relations among such elementary links:
is-relation&concept-total-specialization ($Link_3$, $Link_1$),
is-relation&concept-total-specialization ($Link_4$, $Link_1$),
is-relation&concept-partial-specialization&partial-instantiation ($Link_5$, $Link_2$),
is-concept-partial-specialization ($Link_6$, $Link_1$),
is-relation&concept-partial-specialization ($Link_7$, $Link_1$),
is-concept-partial- specialization ($Link_8$, $Link_1$),
is-same-link ($Link_9$, $Link_1$).

3.7 Relations among Conceptual Graphs

3.7.1 Definitions

Let $CG_1 = (\mathcal{C}_1, \mathcal{R}_1, \mathcal{A}_1)$ and $CG_2 = (\mathcal{C}_2, \mathcal{R}_2, \mathcal{A}_2)$ two conceptual graphs, where $\mathcal{C}_i$ is the set of C-vertices of CG_i, $\mathcal{R}_i$ the set of R-vertices of CG_i and $\mathcal{A}_i$ the set of elementary links of CG_i.

We adapt as follows the definition of graph morphism proposed by Chein and Mugnier, 1992.

Graph morphism

A graph morphism h between CG_1 and CG_2 is a tuple of three functions : $(h_c: \mathcal{C}_1 \rightarrow \mathcal{C}_2, h_r \ \mathcal{R}_1 \rightarrow \mathcal{R}_2, h_a : \mathcal{A}_1 \rightarrow \mathcal{A}_2)$ such that: $\forall\, rel_1 \in \mathcal{R}_1$, $\forall\, i \in [1..arity(rel_1)]$, $h_c(neighbour(i, rel_1)) = neighbour(i, h_r(rel_1))$
and $\forall\, link_1 = rel_1(C_{11}, \ldots C_{1n}) \in \mathcal{A}_1$, $h_a(link_1) = h_r(rel_1)(h_c(C_{11}), \ldots h_c(C_{1n}))$.

1) Subgraph and Supergraph

- CG_2 is a *subgraph* of CG_1 iff there exists a surjective graph morphism (h_c: $\mathcal{C}_1 \to \mathcal{C}_2$, h_r $\mathcal{R}_1 \to \mathcal{R}_2$, h_a : $\mathcal{A}_1 \to \mathcal{A}_2$) such that
  $\forall$ $link_2 = rel_2(C_{21}, \dots C_{2n}) \in \mathcal{A}_2$, $\exists$ $link_1 = rel_1(C_{11}, \dots C_{1n}) \in \mathcal{A}_1$, such that $link_2 = h_a(link_1) \wedge$ is-same-link ($link_2$, $link_1$).

- CG_2 is a *supergraph* of CG_1 iff CG_1 is a *subgraph* of CG_2.

2) Contraction and Expansion

- CG_2 is a *contraction* of CG_1 iff CG_2 is obtained from CG_1 by a contraction of a type definition.

- CG_2 is an *expansion* of CG_1 iff CG_2 is obtained from CG_1 by an expansion of a type definition. CG_2 is an expansion of CG_1 iff CG_1 is a contraction of CG_2.

3) Specialization

- CG_2 is a *"concept total specialization"* of CG_1 iff there exists a surjective graph morphism (h_c: $\mathcal{C}_2 \to \mathcal{C}_1$, h_r $\mathcal{R}_2 \to \mathcal{R}_1$, h_a : $\mathcal{A}_2 \to \mathcal{A}_1$) from CG_2 to CG_1 such that $\forall$ $link_2 \in \mathcal{A}_2$, its image $link_1 = h_a(link_2) \in \mathcal{A}_1$ satisfies : is-concept-total-specialization ($link_2$, $link_1$) (i.e. is-concept-total-generalization ($link_1$, $link_2$)).

- CG_2 is a *"concept partial specialization"* of CG_1 iff there exists a surjective graph morphism (h_c, h_r , h_a) from CG_2 to CG_1 such that $\forall$ $link_2 \in \mathcal{A}_2$, $link_1 = h_a(link_2) \in \mathcal{A}_1$ satisfies : (is-concept-partial-specialization ($link_2$, $link_1$) $\vee$ is-same-link ($link_2$, $link_1$))
  $\wedge \exists$ $link_2 \in \mathcal{A}_2$ the image of which $link_1$ satisfies : is-concept-partial-specialization ($link_2$, $link_1$) .

- CG_2 is a *"relation total specialization"* of CG_1 iff there exists a surjective graph morphism (h_c, h_r , h_a) from CG_2 to CG_1 such that $\forall$ $link_2 \in \mathcal{A}_2$, $link_1 = h_a(link_2) \in \mathcal{A}_1$ satisfies : is-relation-specialization ($link_2$, $link_1$) .

- CG_2 is a *"relation partial specialization"* of CG_1 iff there exists a surjective graph morphism (h_c, h_r , h_a) from CG_2 to CG_1 such that $\forall$ $link_2 \in \mathcal{A}_2$, $link_1 = h_a(link_2) \in \mathcal{A}_1$ satisfies: (is-relation-specialization ($link_2$, $link_1$) $\vee$ is-same-link ($link_2$, $link_1$))
  $\wedge \exists$ $link_2 \in \mathcal{A}_2$ the image of which $link_1$ satisfies : is-relation-specialization ($link_2$, $link_1$)

- CG_2 is a *"relation & concept total specialization"* of CG_1 iff there exists a surjective graph morphism (h_c, h_r , h_a) from CG_2 to CG_1 such that $\forall$ $link_2 \in \mathcal{A}_2$, $link_1 = h_a(link_2) \in \mathcal{A}_1$ satisfies: is-relation&concept-total-specialization ($link_2$, $link_1$).

- CG_2 is a *"relation & concept partial specialization"* of CG_1 iff there exists a surjective graph morphism (h_c, h_r, h_a) from CG_2 to CG_1 such that $\forall$ $link_2 \in \mathcal{A}_2$, $link_1 = h_a(link_2) \in \mathcal{A}_1$ satisfies : (is-relation&concept-partial-specialization ($link_2$, $link_1$) $\vee$ is-same-link ($link_2$, $link_1$)) $\wedge$ $\exists$ $link_1 \in \mathcal{A}_1$ the image of which $link_2$ satisfies : is-relation&concept-partial-specialization ($link_2$, $link_1$).

  All such graph morphisms need not be injective.

4) Generalization

- CG_2 is a *"concept total generalization"* of CG_1 iff CG_1 is a *"concept total specialization"* of CG_2.
- CG_2 is a *"concept partial generalization"* of CG_1 iff CG_1 is a *"concept partial specialization"* of CG_2.
- CG_2 is a *"relation total generalization"* of CG_1 iff CG_1 is a *"relation total specialization"* of CG_2.
- CG_2 is a *"relation partial generalization"* of CG_1 iff CG_1 is a *"relation partial specialization"* of CG_2.
- CG_2 is a *"relation & concept total generalization"* of CG_1 iff CG_1 is a *"relation & concept total specialization"* of CG_2.
- CG_2 is a *"relation & concept partial generalization"* of CG_1 iff CG_1 is a *"relation & concept total specialization"* of CG_2.

5) Instantiation

- CG_2 is a *"total instantiation"* of CG_1 iff $\exists$ a surjective graph morphism (h_c, h_r, h_a) from CG_2 to CG_1 such that $\forall$ $link_2 \in \mathcal{A}_2$, $link_1 = h_a(link_2) \in \mathcal{A}_1$ satisfies : is-total-instantiation ($link_2$, $link_1$) (i.e. is-total-conceptualization ($link_1$, $link_2$)).
- CG_2 is a *"partial instantiation"* of CG_1 iff $\exists$ a surjective graph morphism (h_c, h_r, h_a) from CG_2 to CG_1 such that $\forall$ $link_2 \in \mathcal{A}_2$, $link_1 = h_a(link_2) \in \mathcal{A}_1$ satisfies : is-partial-instantiation ($link_2$, $link_1$) $\vee$ is-same-link ($link_2$, $link_1$)
  $\wedge$ $\exists$ $link_2 \in \mathcal{A}_2$ the image of which $link_1$ satisfies : is-partial-instantiation ($link_2$, $link_1$) .
- CG_2 is a *"relation specialization & total instantiation"* of CG_1 iff $\exists$ a surjective graph morphism (h_c, h_r, h_a) from CG_2 to CG_1 such that $\forall$ $link_2 \in \mathcal{A}_2$, $link_1 = h_a(link_2) \in \mathcal{A}_1$ satisfies :
  is-relation-specialization&total-instantiation ($link_2$, $link_1$).

- CG_2 is a *"relation specialization & partial instantiation"* of CG_1 iff there exists a surjective graph morphism (h_c, h_r, h_a) from CG_2 to CG_1 such that $\forall$ $link_2 \in \mathcal{A}_2$, $link_1 = h_a(link_2) \in \mathcal{A}_1$ satisfies: is-relation-specialization&partial-instantiation ($link_2$, $link_1$) $\vee$ is-same-link ($link_2$, $link_1$) $\wedge$ $\exists$ $link_1 \in \mathcal{A}_1$ the image of which $link_2$ satisfies : relation-specialization& partial-instantiation ($link_2$, $link_1$) .

All such graph morphisms need not be injective.

6) Conceptualization

- CG_2 is a "*total conceptualization"* of CG_1 iff CG_1 is a "*total instantiation"* of CG_2.
- CG_2 is a *"partial conceptualization"* of CG_1 iff CG_1 is a "*partial instantiation"* of CG_2.
- CG_2 is a *"relation generalization & total conceptualization"* of CG_1 iff CG_1 is a "*relation specialization & total instantiation"* of CG_2.
- CG_2 is a *"relation generalization & partial conceptualization"* of CG_1 iff CG_1 is a "*relation specialization & partial instantiation"* of CG_2.

Of course, all such relations amnong CGs correspond to particular cases of projection of a CG into another.

3.8 Construction of the Base of Integrated Conceptual Graphs

3.8.1 Strategies of Integration

Once obtained the relationships between elementary links of both graphs, the integration builds the integrated graph CG_{com}.The integration of two conceptual graphs must be guided by a *strategy* for solving conflicts: a given strategy can be chosen if its preconditions are satisfied. In case of choice between two comparable elementary links $link_1 = rel_1(C_{11}, ..., C_{1n}) \in \mathcal{A}_1$, and $link_2 = rel_2(C_{21}, ..., C_{2n}) \in \mathcal{A}_2$ among which there exists at least one relation, the elementary link to be stored in the integrated conceptual graph depends on the relation between both links and on the chosen integration strategies.

- *Strategy of the highest direct generalization*:
  If there exists a global relation of generalization between both CGs, the most general of both CGs is chosen.
  Otherwise, only the following relations between elementary links are successively considered:
  1) is-relation&is-concept-total-generalization, is-relation&concept-total-specialization,
  2) is-relation&concept-partial-generalization, is-relation&concept-partial-specialization,
  3) is-relation-generalization, is-relation-specialization,

4) is-concept-total-generalization, is-concept-total-specialization,
5) is-concept-partial-generalization, is-concept-partial-specialization.
The knowledge engineer chooses the "most general" between $link_1$ and $link_2$, to include in CG_{com}, while respecting what was said by at least one expert. It corresponds to the result of the function *most-general* ($link_1$, $link_2$). If the function gives no result, both links $link_1$ and $link_2$ are included in CG_{com}.
Preconditions: An expert focuses on particular cases, while the other expert expresses general knowledge, valid in more general cases. The knowledge engineer prefers to always restrict to what was explicitly expressed by at least one expert: he takes no initiative for generalizing the knowledge expressed by an expert.

- *Strategy of the highest indirect generalization*:
  If there exists a global relation of generalization between both CGs, the most general of both CGs is chosen.
  Otherwise, the same relations as in the previous case are considered.
  The knowledge engineer includes the result of the function *common-generalization* ($link_1$, $link_2$) in the integrated CG. It corresponds to the "minimal generalization" common to $link_1$ and $link_2$, but in this strategy, the knowledge engineer may take the initiative to replace type (rel_1) and type (rel_2) by their minimal common supertype i.e. type (rel_1) $\cup$ type (rel_2) and to replace type (neighbour (i,rel_1)) and type (neighbour (i,rel_2)) by their minimal common supertype i.e. type (neighbour (i,rel_1)) $\cup$ type (neighbour (i,rel_2)).

  Preconditions: The characteristics of the expert are the same as in the previous case. In case of need, the knowledge engineer is allowed to take the initiative for generalizing the knowledge expressed by an expert: he must be guided by the other expert's knowledge.

- *Strategy of the highest direct specialization*:
  If there exists a global relation of specialization between both CGs, the most specialized of both CGs is chosen.
  Otherwise, the same relations as in the previous case are considered.
  The knowledge engineer chooses the "most specialized" between $link_1$ and $link_2$, to include in the integrated CG. It corresponds to the result of the function *most-specific* ($link_1$, $link_2$).
  In this strategy, the knowledge engineer always respects what was said by at least one expert.

  Preconditions: An expert is more specialized than the other, on a given aspect and uses more precise expressions. The knowledge engineer prefers to restrict to what was explicitly expressed by at least one expert: he takes no initiative for specializing the experts' knowledge or for restricting its validity.

- *Strategy of the highest indirect specialization*:
  If there exists a global relation of specialization between both CGs, the most specialized of both CGs is chosen.
  Otherwise, the same relations as in the previous case are considered.
  The knowledge engineer includes the result of the function *common-specialization* ($link_1$, $link_2$)

in the integrated CG. It corresponds to the "maximal specialization" common to $link_1$ and $link_2$, but in this strategy, the knowledge engineer can take the initiative to use, instead of type (rel_1) and type (rel_2), their maximal common subtype i.e. type (rel_1) $\cap$ type (rel_2), or to use, instead of type (neighbour (i,rel_1)) and type (neighbour (i,rel_2)), their maximal common subtype i.e. type (neighbour (i,rel_1)) $\cap$ type (neighbour (i,rel_2)).

Preconditions: The preconditions on the experts are the same as in the previous case. In case of need, the knowledge engineer can exploit the knowledge expressed by an expert, in order to specialize the other expert's knowledge or to restrict its validity domain.

- *Strategy of the highest direct conceptualization :*
  If there exists a global relation of conceptualization between both CGs, the most"conceptualized" of both CGs is chosen.
  Otherwise, only the following relations between elementary links are successively considered:
  1) is-relation-generalization&total-conceptualization, is-relation-generalization&total-instantiation,
  2) is-relation-generalization&partial-conceptualization, is-relation-generalization&partial-instantiation,
  3) is-total-conceptualization, is-total-instantiation,
  4) is-partial-conceptualization, is-partial-instantiation.
  The knowledge engineer includes the result of the function *most-generic* ($link_1$, $link_2$) in CG_{com}.
  If the function gives no result, both links $link_1$ and $link_2$ are included in CG_{com}.
  Preconditions: An expert focuses on too particular cases and on too specific examples, while the other expert expresses general knowledge, at a better level of abstraction. The knowledge engineer prefers to always restrict to what was explicitly expressed by at least one expert: he takes no initiative for generalizing the knowledge expressed by an expert.

- *Strategy of the highest indirect conceptualization :*
  If there exists a global relation of conceptualization between both CGs, the most "conceptualized" of both CGs is chosen.
  Otherwise, the same relations as in the previous case are considered.
  The knowledge engineer includes the result of the function *common-conceptualization* ($link_1$, $link_2$) in the integrated CG. It corresponds to the "minimal conceptualization" common to $link_1$ and $link_2$, but in this strategy, the knowledge engineer can take the initiative to replace referent (neighbour (i,rel_1)) and referent (neighbour (i,rel_2)) by a generic referent.
  Preconditions: An expert focuses on particular cases, while the other expert expresses general knowledge, valid in more general cases. The knowledge engineer prefers to always restrict to what was explicitly expressed by at least one expert: he takes no initiative for generalizing the knowledge expressed by an expert.

- *Strategy of the highest direct instantiation* *:

* The definition of a strategy of the highest indirect instantiation seems difficult.

If there exists a global relation of instantiation between both CGs, the most"instantiated" of both CGs is chosen.
Otherwise, the relations to consider are the same relations as in the previous case.
The knowledge engineer chooses the "most instantiated" between $link_1$ and $link_2$, to include in the integrated CG. It corresponds to the result of the function *most-instantiated* ($link_1$, $link_2$).
In this strategy, the knowledge engineer always respects what was said by at least one expert.

Preconditions: An expert gives useful and precise examples. The knowledge engineer prefers to restrict to what was explicitly expressed by at least one expert: he takes no initiative for specializing the experts' knowledge or for restricting its validity.

- *Strategy of the greatest confidence*:
  If one expert is known as more specialist on a given field than the other, choose his vision in case of conflict.
  So, in the integrated CG, keep $link_1$ or $link_2$ according to the competent expert.

  Precondition: an expert has a higher level of competence in a given field.

- *Strategy of experts' consensus*:
  Reject both nodes, unless both experts agree on which one to choose.

  Preconditions: (1) Both experts have the same level of competence in the considered field and the knowledge engineer has no criterion for choosing one rather than the other. (2) Or, for "psychological" reasons, it is impossible to make a selection between both experts. (3) Or, the future KBS is explicitly aimed at relying only on the intersecting knowledge of both experts.

The knowledge engineer chooses the integration strategy, according to the individual characteristics of the experts and to their expertises: their specialities, the way they expressed during the elicitation sessions (level of precision, abstraction of their expressions, presence or absence of examples illustrating abstract knowledge, capability to abstract knowledge from particular cases...). The integration strategy may be global, and be applied throughout the integration algorithm, or, on the contrary, it may be local and change according to the context. So, throughout a given integration, the previously described integration strategies may be combined. When several strategies are possible, the knowledge engineer must make his choice with the help of the experts. For example, in traffic accident analysis, if the two psychologists are known as specialists of GTI vehicle drivers and of drivers' errors respectively, we can adopt (a) the strategy of the greatest confidence when comparing parts of the knowledge graphs concerning drivers of the GTI vehicles or drivers' errors, (b) otherwise, the strategy of the highest direct specialization whenever it can be applied, (c) and the strategy of experts' consensus in the remaining cases.

3.8.2 Building of the Integrated Conceptual Graphs

For integration CG_1 and CG_2, examine the relations between the two sets of elementary links $\mathcal{A}_1$ and $\mathcal{A}_2$. According to the integration strategy, only some relations will be useful. Moreover, there is a priority between the relations. The purpose is to find a matching function : $\mathcal{A}_1 \rightarrow \mathcal{A}_2$ that

allows a matching of a link of CG_1 into a link of CG_2.
Several cases are possible :
- If for each $link_1 \in \mathcal{A}_1$, it remains at most one relation linking $link_2 \in \mathcal{A}_2$ with $link_1$, then the matching function : $\mathcal{A}_1 \rightarrow \mathcal{A}_2$ will link $link_1$ to $link_2$.
- In case of multiple such relations, eliminate some of them in order to find a matching function : $\mathcal{A}_1 \rightarrow \mathcal{A}_2$ (i.e. a combination such that each $link_2 \in \mathcal{A}_2$ is the image of at most one $link_1 \in \mathcal{A}_1$).

At the end, the different parts of the obtained integrated CG must be connected thanks to a maximal join.

3.9 Example

With the previous example (cf. figure 4):

- CG_1 is a «relation total generalization & concept partial generalization & partial conceptualisation» of CG_2.
- CG_2 is a «relation total specialization & concept partial specialization & partial instantiation» of CG_1.

Therefore, with the strategy of the highest (direct or indirect) generalization, the integrated graph of CG_1 and CG_2 is CG_1. With the strategy of the highest (direct or indirect) specialization, the integrated graph is CG_2.

Likewise, with this example of figure 4, the integrated graph from CG_1 and CG_3 is CG_1 with the strategy of the highest generalization. With the strategy of the highest specialization, the integrated graph of CG_1 and CG_3 is shown in figure 5.

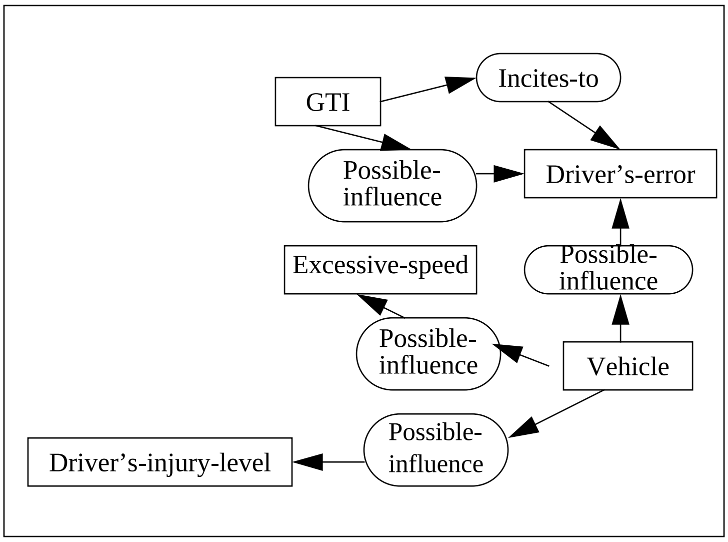


Figure 5: Integrated graph of CG_2 and CG_3

3.10 Influence on the Agents

If successful, the algorithm of comparison of the different conceptual graphs of the same viewpoint leads to integrated conceptual graphs, according to the integration strategy. Then a new agent can be built, having as expertise knowledge the knowledge common to both experts, i.e. described in the domain layer by the integrated conceptual graphs. The remaining parts of each expert (for example, when he owned a conceptual graph for a viewpoint that did not exist for the other expert) constitute his specific knowledge and can be gathered in a new agent corresponding to this expert's specificities (and called agent specific to this expert). For example, for the house building, after comparison of the experts in electricity and in mechanics, the "electrical viewpoint conceptual graph" of the expert in electricity will not be part of the expertise of the common agent and will remain in the electrician's specific agent. We can then consider that each of the two experts that were compared is now a compound agent, made of the common agent and the specific agent.

3.11 Extensions

The algorithm of comparison of two conceptual graphs can be refined, so as to take into account several experts. Several approaches seem possible:

- compare the experts progressively, by always comparing two agents: first compare two of the experts, chosen according to an adequate strategy, then compare a third one with the common agent obtained after comparison of the first two experts, etc.

- compare the experts all together directly,
- partition the set of the experts into n subsets, according to an adequate criterion (such as the experts' specialization on a given subject), and then associate to each subset the common agent obtained by the comparison of the agents of this subset, and, lastly, compare the n common agents obtained. Notice that, within a given subset, the agents may again be compared either progressively, or directly, or after a new partitioning.

4 Conclusions

4.1 Related Work

In this paper, we proposed an algorithm for comparison of conceptual graphs representing knowledge of several experts. Terminology conflicts due to the possibility of disagreement of the experts on some concepts or on the vocabulary were studied in (Shaw and Gaines (1989); Gaines and Shaw (1989)): the authors offer a method for comparing the different conceptual systems of the experts. They define the notions of consensus, conflicts, correspondences and contrasts and propose a method for detecting these different aspects. For our detection of terminology conflicts, we take inspiration of a part of this work. In Easterbrook (1989) a multi-agents architecture is used in order to allow the coexistence of multiple perspectives / viewpoints in the framework of distributed knowledge acquisition. Techniques for comparing several viewpoints and solving conflicts among them are described in Easterbrook (1991). The techniques used for integrating new knowledge into an existing knowledge base (Eggen et al (1990) ; Murray and Porter (1990)) can be relevant for integration of knowledge from multiple experts. A method for building a common ontology from multiple ontologies on the same domain is described in Kayaalp and Sullins (1994). In Wiederhold (1994), the author presents an algebra over ontologies, with a set of operations for matching and integration ontologies. In (Mineau & al, 1995), the authors study the integration of vocabularies.

Our techniques of comparison between several conceptual graphs representing the viewpoints of several experts seem to offer a rather different approach from such previous research on terminology conflicts, on integration of several knowledge sources, or on conflict management. They also differ from the techniques and tools for cooperative design, described in (Klein (1989); Klein (1992)), and allowing to detect and solve conflicts among design agents (that may be human agents or machine-based agents). As they exploit conceptual graph formalism, they can be compared to research on graph isomorphism and on algorithms for matching conceptual graphs (Poole and Campbell (1995); Willems (1995); Cogis and Guinaldo (1995)) or for merging conceptual graphs (Garner and Lukose, 1992). Our research has also a link with the work on the building of shared or common ontologies (Gruber (1993), Garcia (1995).

4.2 Further work

As a further extension, for each agent, we will admit several conceptual graphs for a given viewpoint. As a further work, we will refine the conceptual graph comparison algorithm, and in particular, study more complex integration strategies and more complex conceptual graphs and extend the algorithm to more than two experts. For each agent, we will admit several conceptual graphs for a given viewpoint. We will study the influence of the experts' comparison order and the possible convergence towards a "minimal" common knowledge. Last, we will exploit a formalization of relations among conceptual graphs (Ribière et al, 1996).

5 Appendix: Example in Traffic Accident Analysis

We elicited knowledge from several experts of INRETS: two psychologists (E-psy1 and E-psy2) , three engineers in road infrastructure (E-infra1, E-infra2 and E-infra3) and two vehicle engineers (E-véh1 and E-véh2). We modelled a part of their expertise on road accident analysis through conceptual graphs. This appendix shows examples of the obtained base of conceptual graphs.

For each expert:

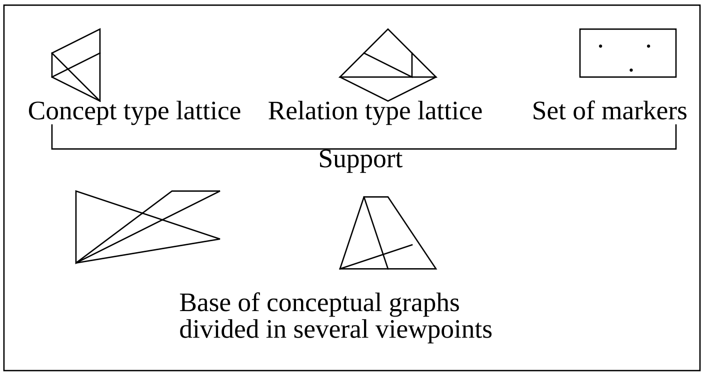


Figure 5: Expertise model of an agent.

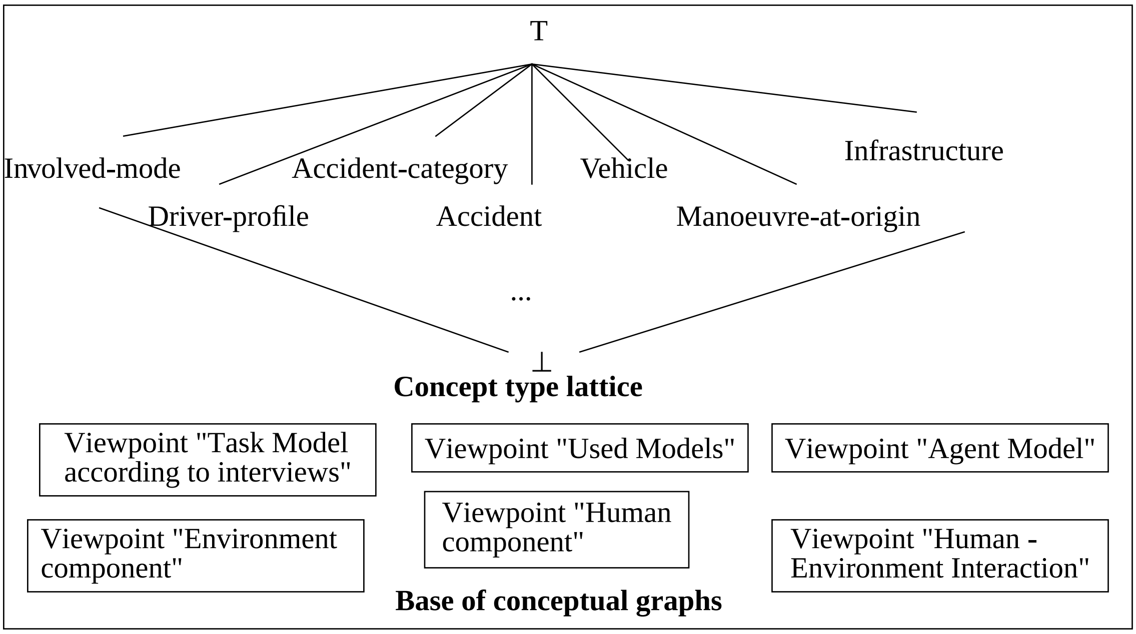


Figure 6 : Expertise of E-infra1

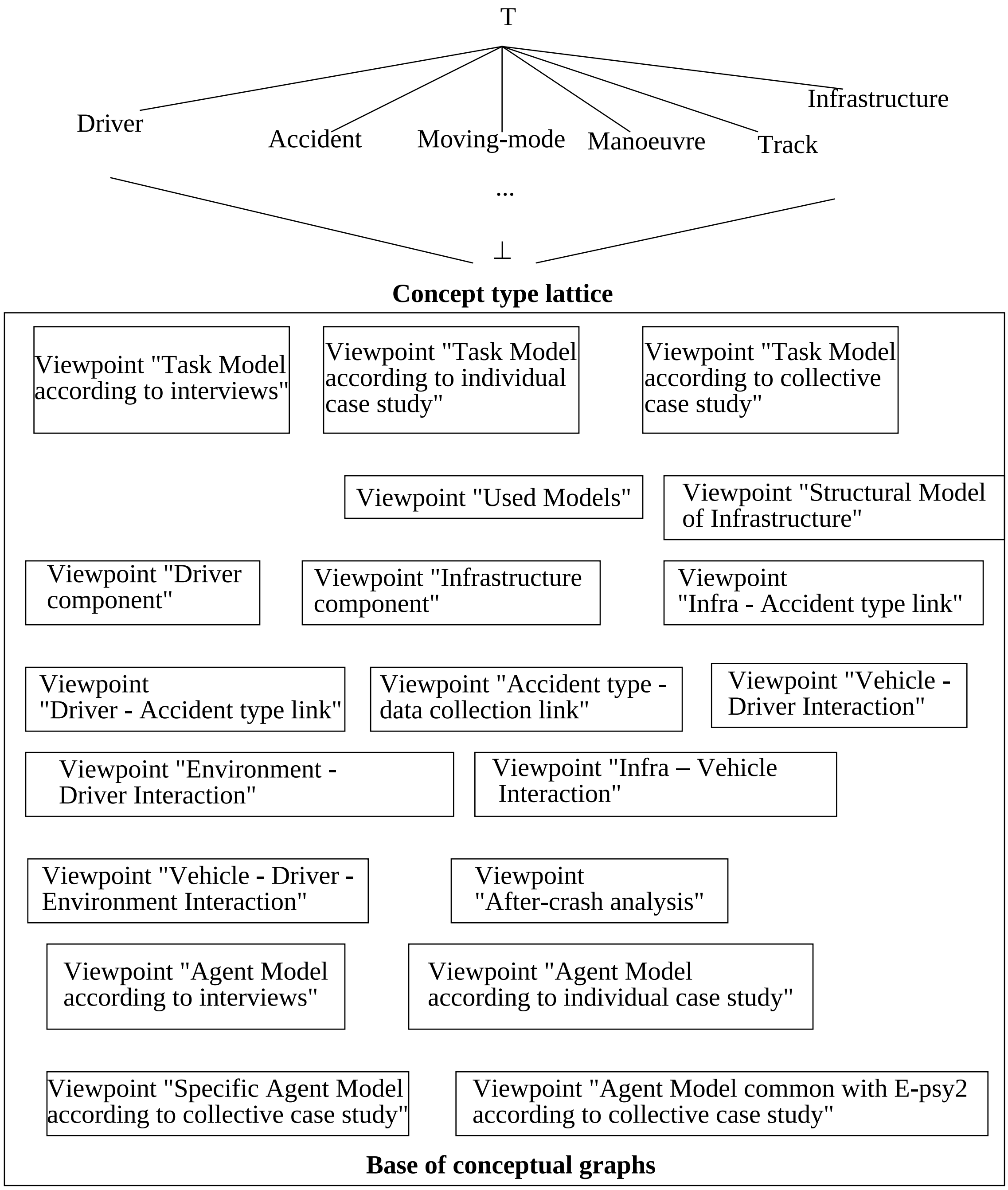


Figure 7 : Expertise of E-infra2

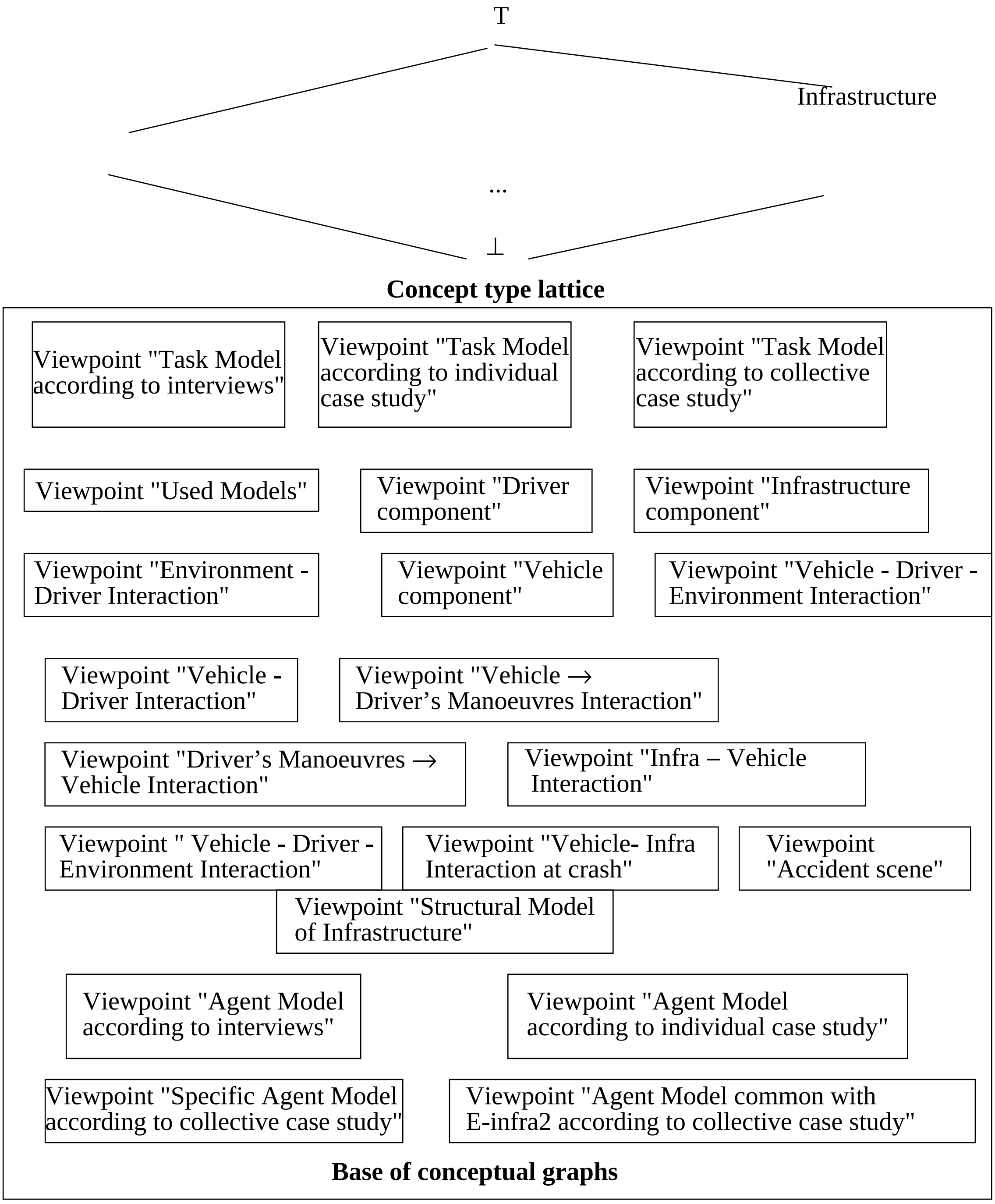
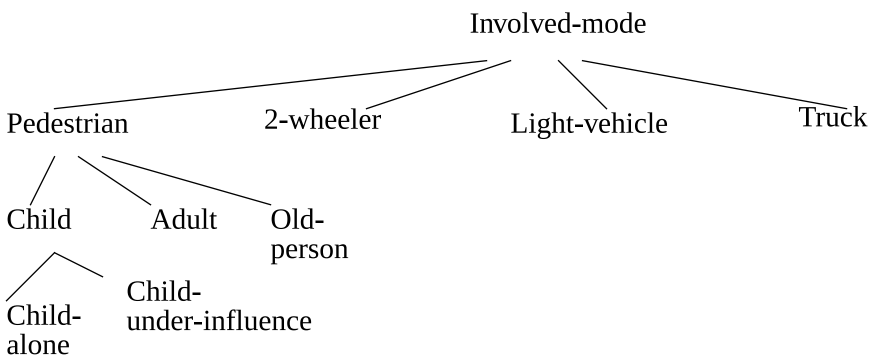


Figure 8: Expertise of E-psy2

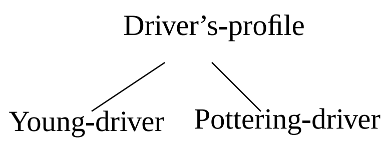
5.1 Type Concept Hierarchies of the Experts

Of course, the hierarchies presented below are far from being complete. The reader can complete them with the concept types appearing in the varied conceptual graphs described throughout this appendix (in particular, the conceptual graphs corresponding to the different experts' expertise rules).

5.1.1 E-infra1's Involved-mode type hierarchy*

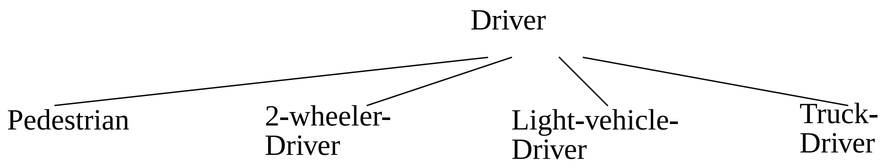


5.1.2 E-infra1's Driver-profile type hierarchy



* I thank specially Sylvie Després as all the examples concerning E-infra1 in this report are entirely based on the modelling she performed on this expert's knowledge.

5.1.3 E-infra2's Driver type hierarchy



Type definitions:

type Pedestrian (x) is [Driver : *x] → (moving-with) → [Feet]

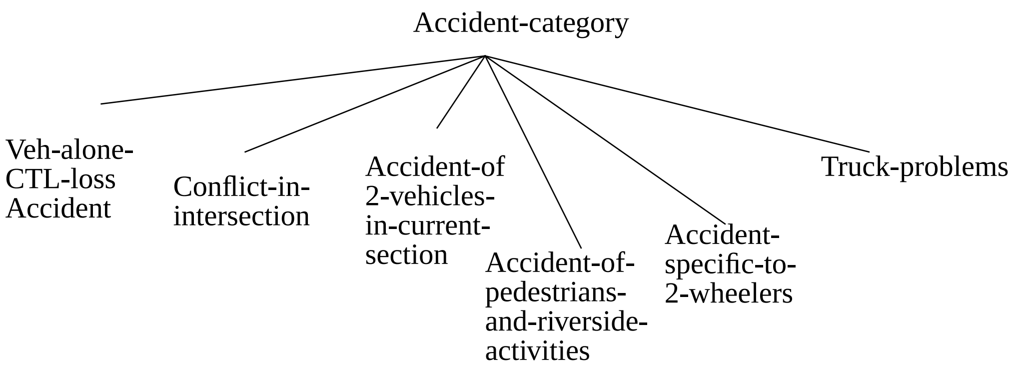
type 2-wheeler-Driver (x) is [Driver : *x] → (moving-with) → [2-wheeler : *y]

type Light-vehicle-Driver (x) is [Driver : *x] → (moving-with) → [Light-vehicle : *y]

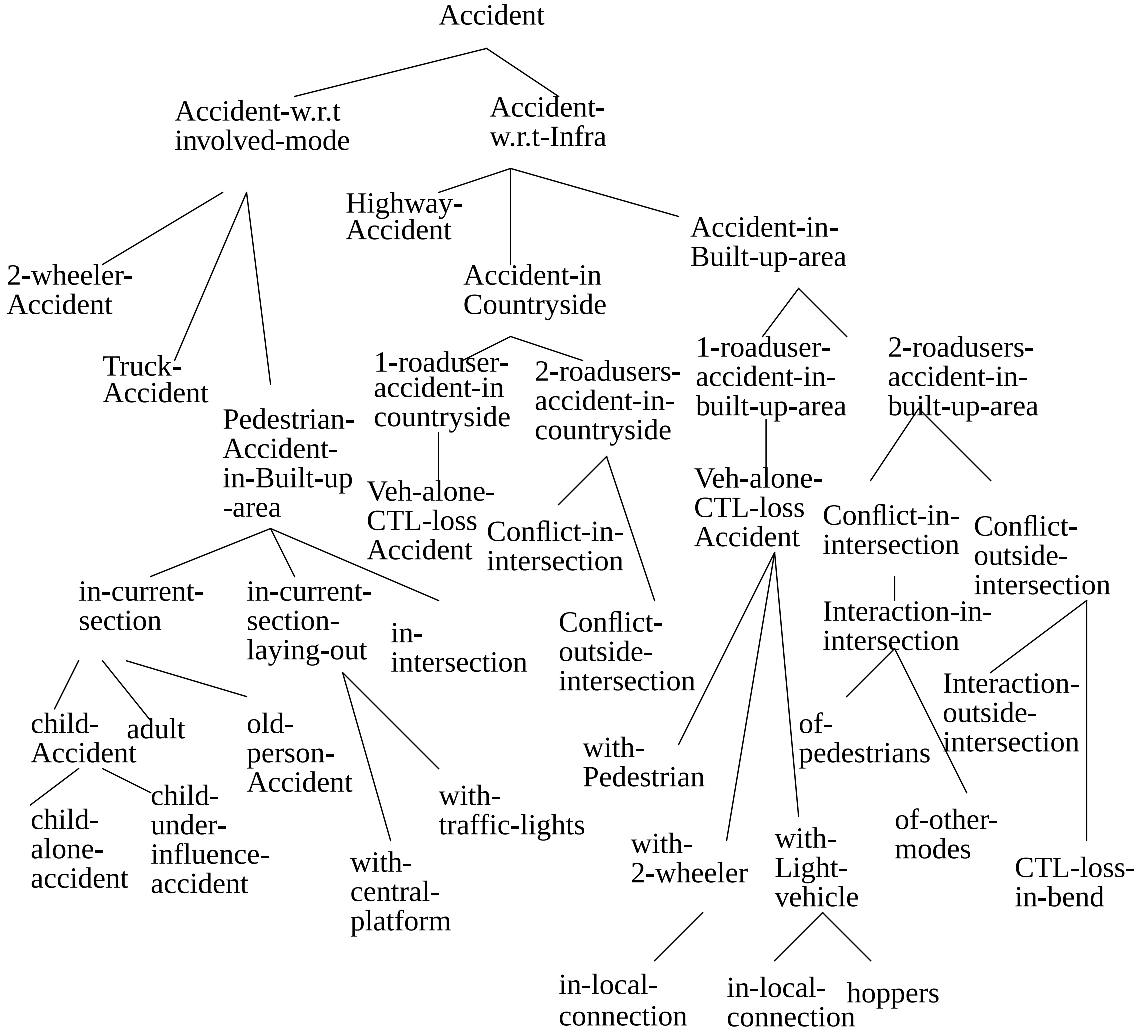
type Truck-Driver (x) is [Driver : *x] → (moving-with) → [Truck : *y]

5.1.4 E-infra1's Model of Accidents

E-infra1's Accident Categories

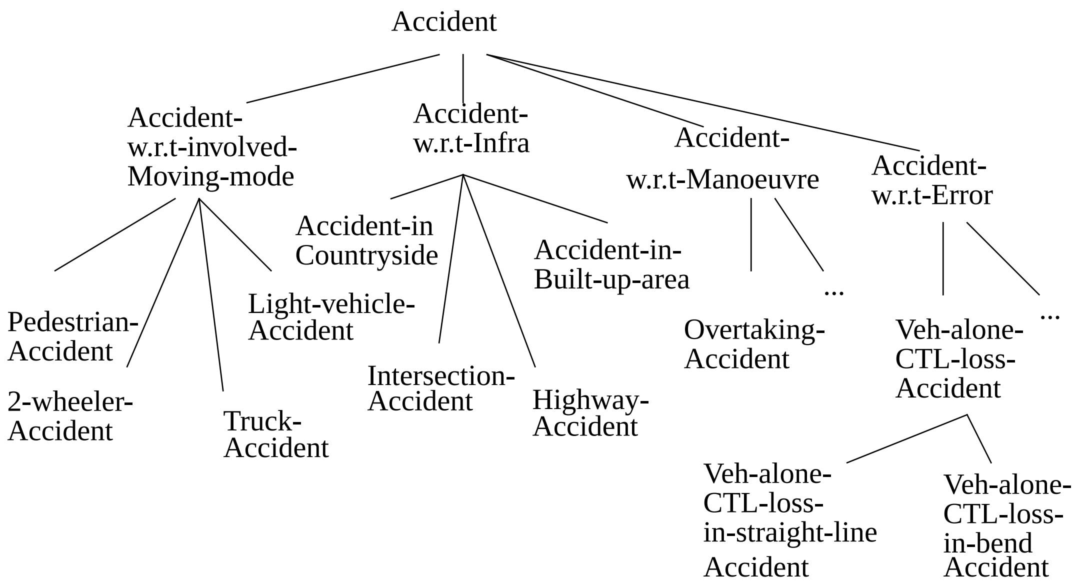


E-infra1's Accident Type hierarchy



For sake of simplicity, in the figures, we don't repeat the term "accident" in each concept name.

5.1.5 E-infra2's Accident Type hierarchy



Typical condition for Accident (x) is
[Accident : *x] - { → (involved-pers) → [Person : *h] → (moving-with) → [Moving-mode : *v]
→ (involved-vehicle) → [Moving-mode : *v]
→ (localized) → [Infrastructure : *i]
→ (after-manoeuvre) → [Manoeuvre : *man]
→ (has-driver-factor) → [Driver-Factor : *driv-fact]
→ (has-vehicle-factor) → [Vehicle-Factor : *veh-fact]
→ (has-infra-factor) → [Infra-Factor : *infra-fact] }

type Pedestrian-Accident (x) is [Accident : *x] → (involved-pers) → [Pedestrian : *h]

type 2-wheeler-Accident (x) is [Accident : *x] → (involved-pers) → [2-wheeler-Driver : *h]

type Truck-Accident (x) is
[Accident : *x] → (involved-pers) → [Truck-Driver : *h]

type Light-vehicle-Accident (x) is
[Accident : *x] → (involved-pers) → [Light-vehicle-Driver : *h]

type Accident-in-countryside (x) is [Accident : *x] → (localized) → [Countryside : *i]

type Intersection-Accident (x) is [Accident : *x] → (localized) → [Crossroad : *i]

type Highway-Accident (x) is [Accident : *x] → (localized) → [Highway : *i]

type Accident-in-Built-up-area (x) is
[Accident : *x] → (localized) → [Road-in-Built-up-area : *i]

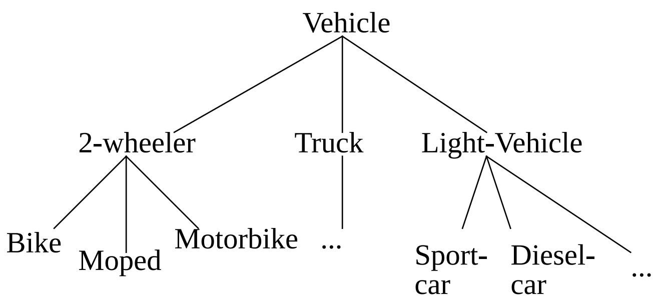
type Overtaking-Accident (x) is [Accident : *x] → (after-manoeuvre) → [Overtaking : *man]

type Veh-alone-CTL-loss-Accident (x) is
[Accident : *x] → (has-driver-factor) → [Vehicle-alone-control-loss : *driv-fact]

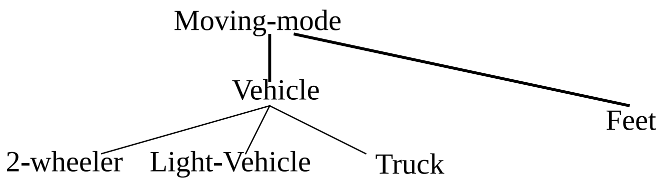
type Veh-alone-CTL-loss-in-straight-line-Accident (x) is
[Accident : *x] - { → (has-driver-factor) → [Vehicle-alone-control-loss : *driv-fact]
→ (involved-pers) → [Driver : *h] → (moving-with) → [Vehicle : *v]
→ (localized) → [Straight-line : *i]}

type Veh-alone-CTL-loss-in-bend-Accident (x) is
[Accident : *x] - { → (has-driver-factor) → [Vehicle-alone-control-loss : *driv-fact]
→ (involved-pers) → [Driver : *h] → (moving-with) → [Vehicle : *v]
→ (localized) →[Bend : *i]}

5.1.6 E-infra1's Vehicle Type Hierarchy



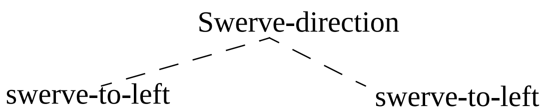
5.1.7 E-infra2's Moving-mode Type Hierarchy

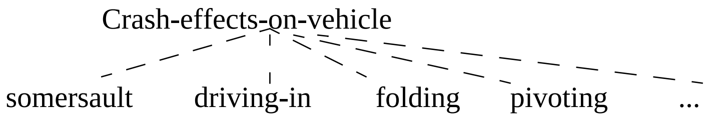


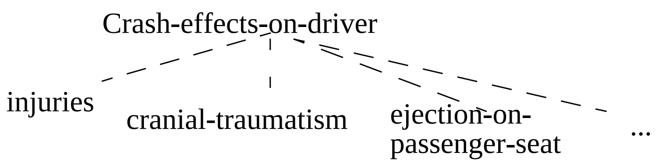
5.1.8 E-infra2's Model of Crash

Typical-conditions for Crash(x) is
[Crash : *x] - { → (chrc) → [Vehicle-position-at-crash]
→ (chrc) → [Collision-point]
→ (chrc) → [Crash-moment-w.r.t.-driver's-crossing]
→ (chrc) → [Impact-angle]
→ (chrc) → [Impact-speed]
→ (chrc) → [Swerve-direction]
→ (chrc) → [Exhaust-length]
→ (chrc) → [Exhaust-angle]
→ (chrc) → [Energy-consumed-at-crash]
→ (chrc) → [Violence]
→ (chrc) → [Crash-effects-on-vehicle]
→ (chrc) → [Crash-effects-on-driver]}

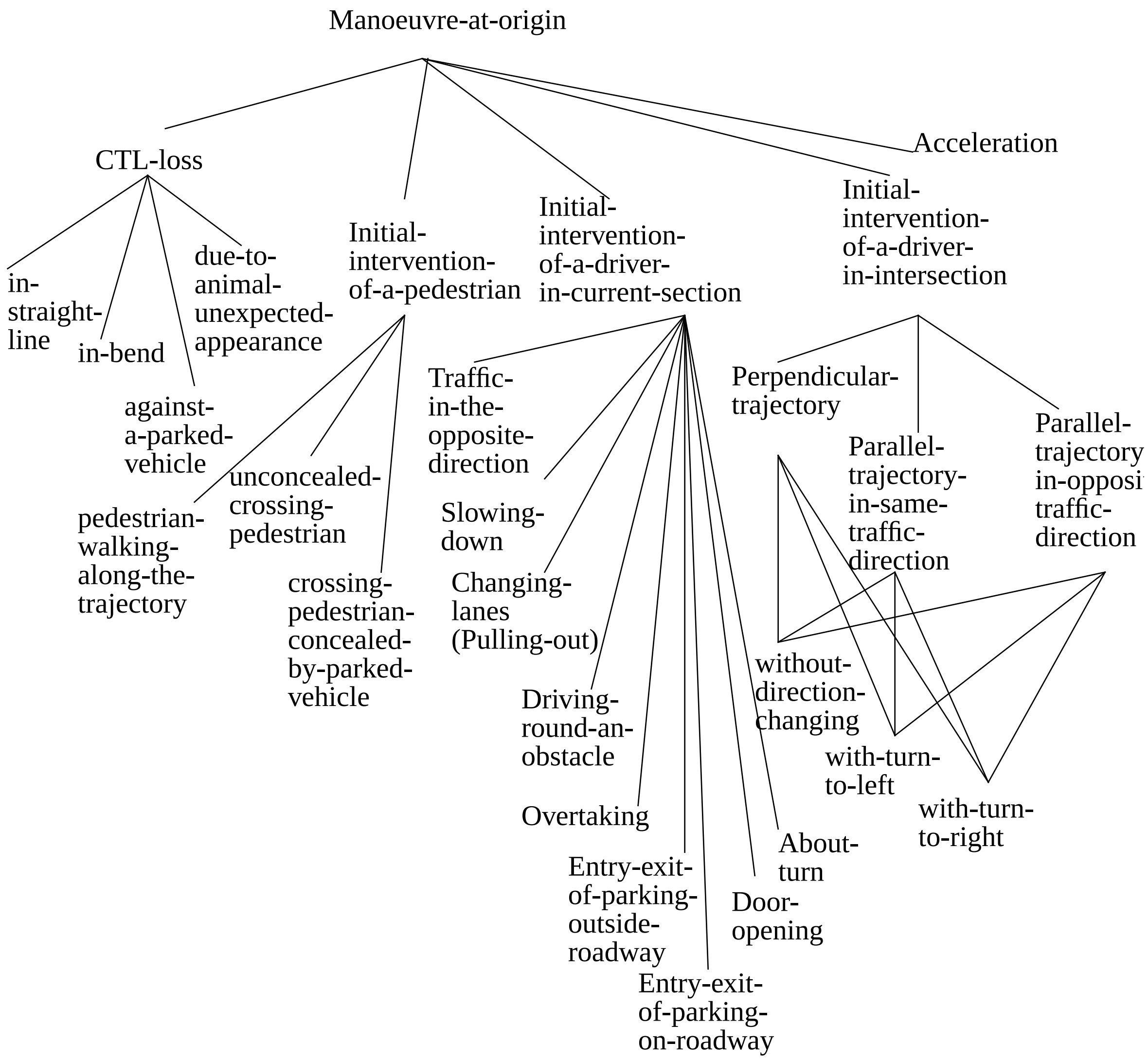
Markers conform to types:



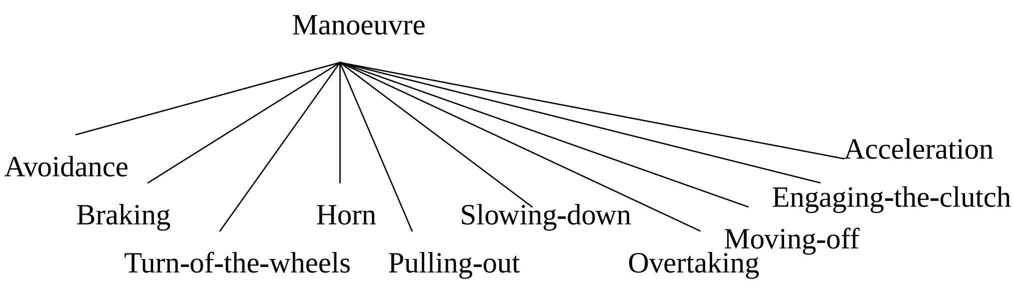




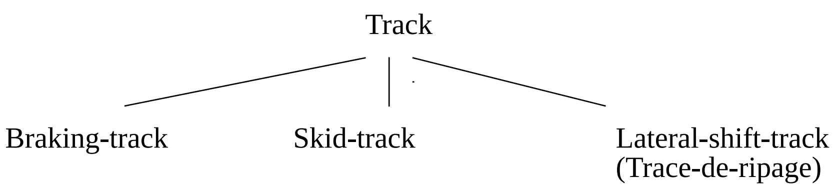
5.1.9 E-infra1's Model of the Manoeuvre at the Origin of the Accident



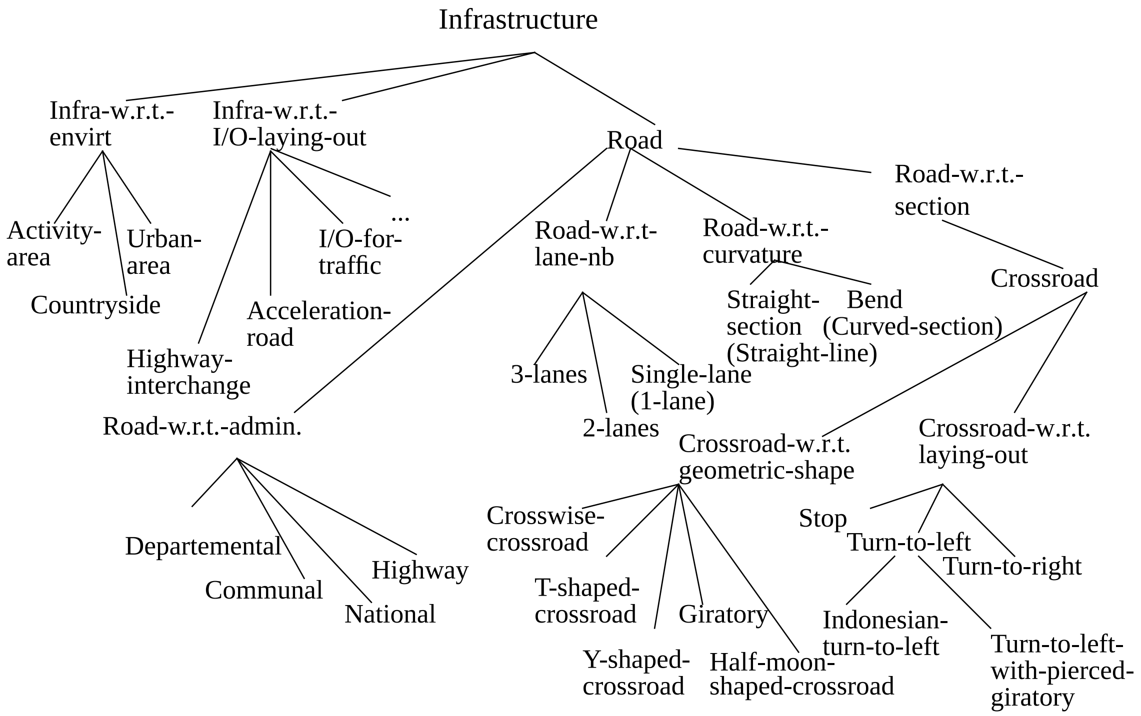
5.1.10 E-infra2's Manoeuvre Type Hierarchy



5.1.11 E-infra2's Track Type Hierarchy



5.1.12E-psy2's Infrastructure Type Hierarchy

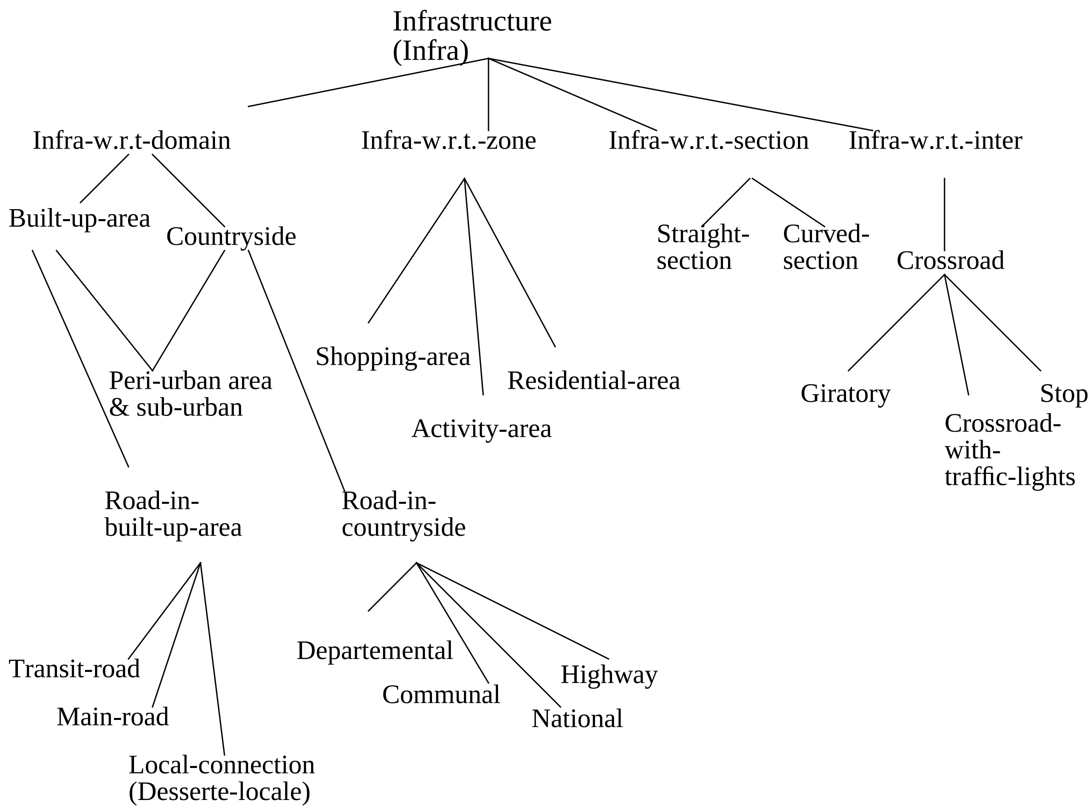


type 3-lanes is [Road-w.r.t-lane-nb] → (chrc) → [Lanes : {*}@3]

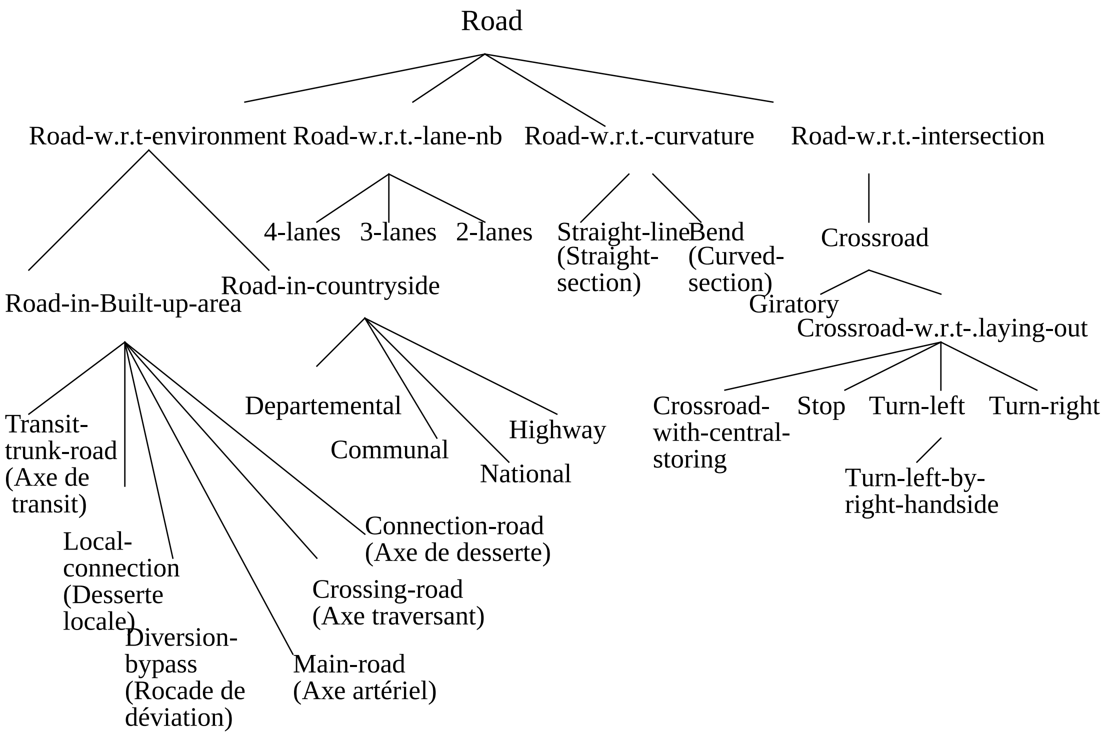
type 2-lanes is [Road-w.r.t-lane-nb] → (chrc) → [Lanes : {*}@2]

type Single-lane is [Road-w.r.t-lane-nb] → (chrc) → [Lanes : {*}@1]

5.1.13E-infra1's Infrastructure Type Hierarchy



5.1.14E-infra2's Infrastructure Type hierarchy



type 4-lanes is [Road-w.r.t-lane-nb] → (chrc) → [Lanes : {*}@4]

type 3-lanes is [Road-w.r.t-lane-nb] → (chrc) → [Lanes : {*}@3]

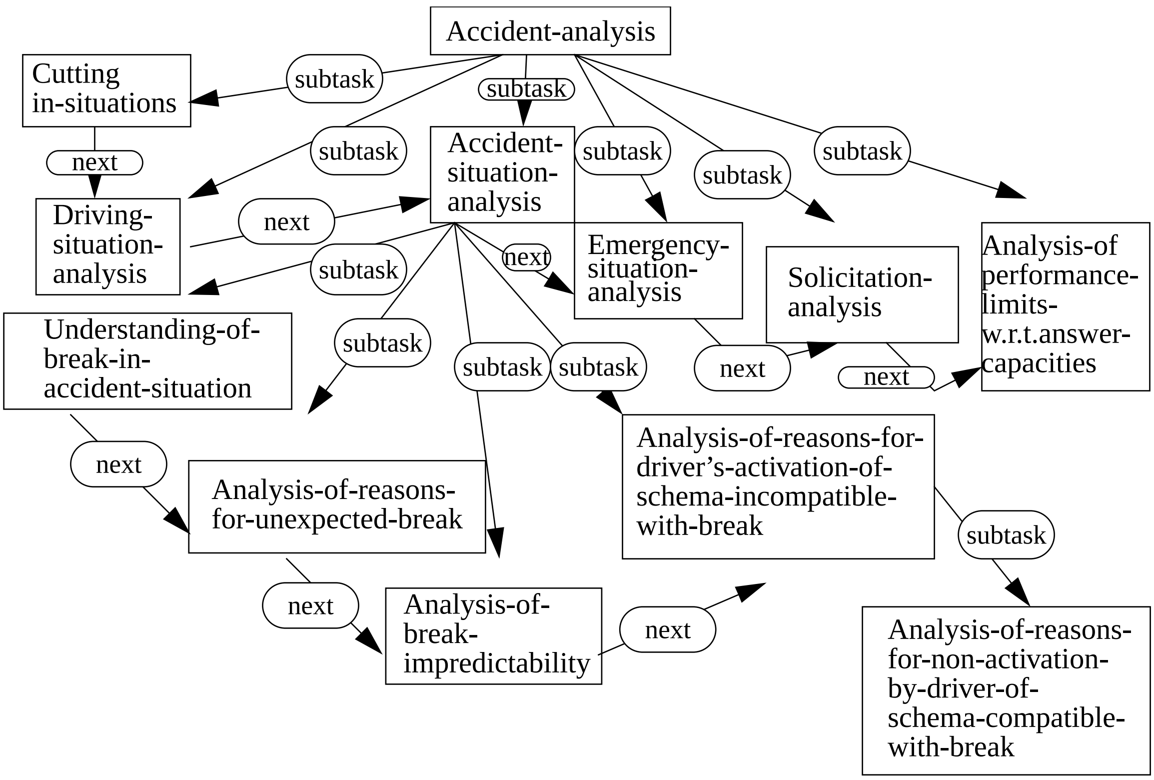
type 2-lanes is [Road-w.r.t-lane-nb] → (chrc) → [Lanes : {*}@2]

5.1.15E-infra2's Structural Model of the Infrastructure

Typical-conditions for Road (x) is
[Road : *x] - { → (chrc) → [Route]
→ (chrc) → [Curvature-radius]
→ (chrc) → [Crosswise-profile]
→ (chrc) → [Profile-in-length]
→ (chrc) → [Lane] → (chrc) → [Lane-width]
→ (chrc) → [Roadway] -{→ (chrc) → [Roadway-access]
→ (chrc) → [Roadway-marking]
→ (chrc) → [Grip-on-roadway]
→ (chrc) → [Roadway-smoothness]
→ (chrc) → [Roadway-width]
→ (chrc) → [Roadway-humidity]}
→ (chrc) → [Shoulder] - {→ (chrc) → [Shoulder-width]
→ (chrc) → [Shoulder-nature]
→ (chrc) → [Shoulder-practicability]}
→ (chrc) → [Coat]
→ (chrc) → [Slope]
→ (chrc) → [Hill]
→ (chrc) → [Declivity]
→ (chrc) → [Visibility]
→ (chrc) → [Visibility-area]
→ (chrc) → [Visibility-distance]
→ (chrc) → [Visibility-loss]
→ (chrc) → [Shadow-area]
→ (chrc) → [Profile-in-long]
→ (chrc) → [Flow]
→ (chrc) → [Roadsigns]
→ (chrc) → [Same-flow-section]
→ (chrc) → [Laying-out]
→ (chrc) → [Surface-feature]
→ (chrc) → [Parking]
→ (chrc) → [Light]
→ (chrc) → [Environment]}

5.2 Task Models of the Experts

5.2.1 E-psy2's Task Model according to his Interviews and Texts



In linear notation :

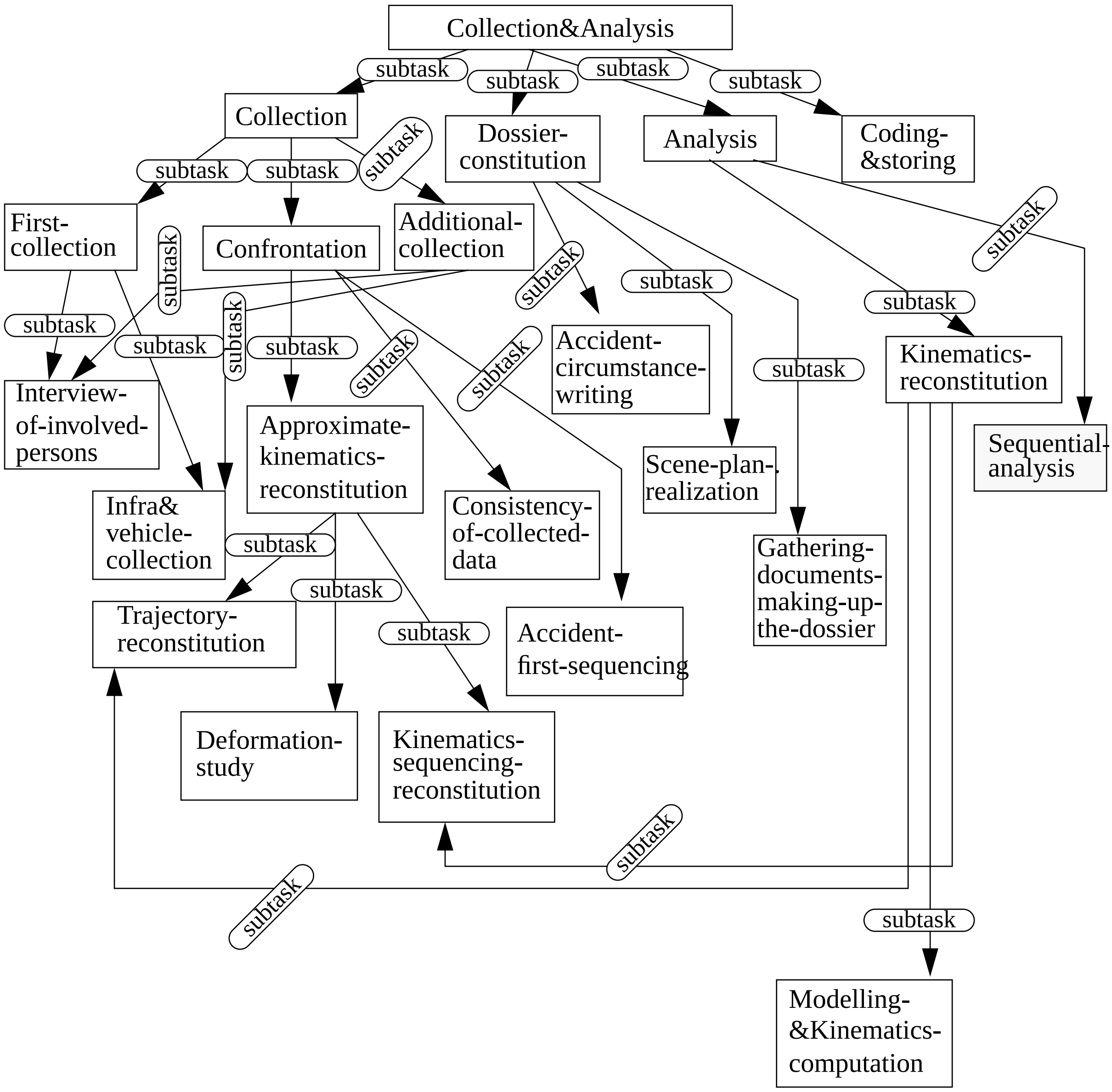
[Accident-analysis] - { → (subtask) → [Cutting-in-situations]
→ (subtask) → [Driving-situation-analysis]
→ (subtask) → [Accident-situation-analysis]
→ (subtask) → [Emergency-situation-analysis]
→ (subtask) → [Solicitation-analysis]
→ (subtask) → [Analysis-of-performance-limits-w.r.t.answer-capacities]}

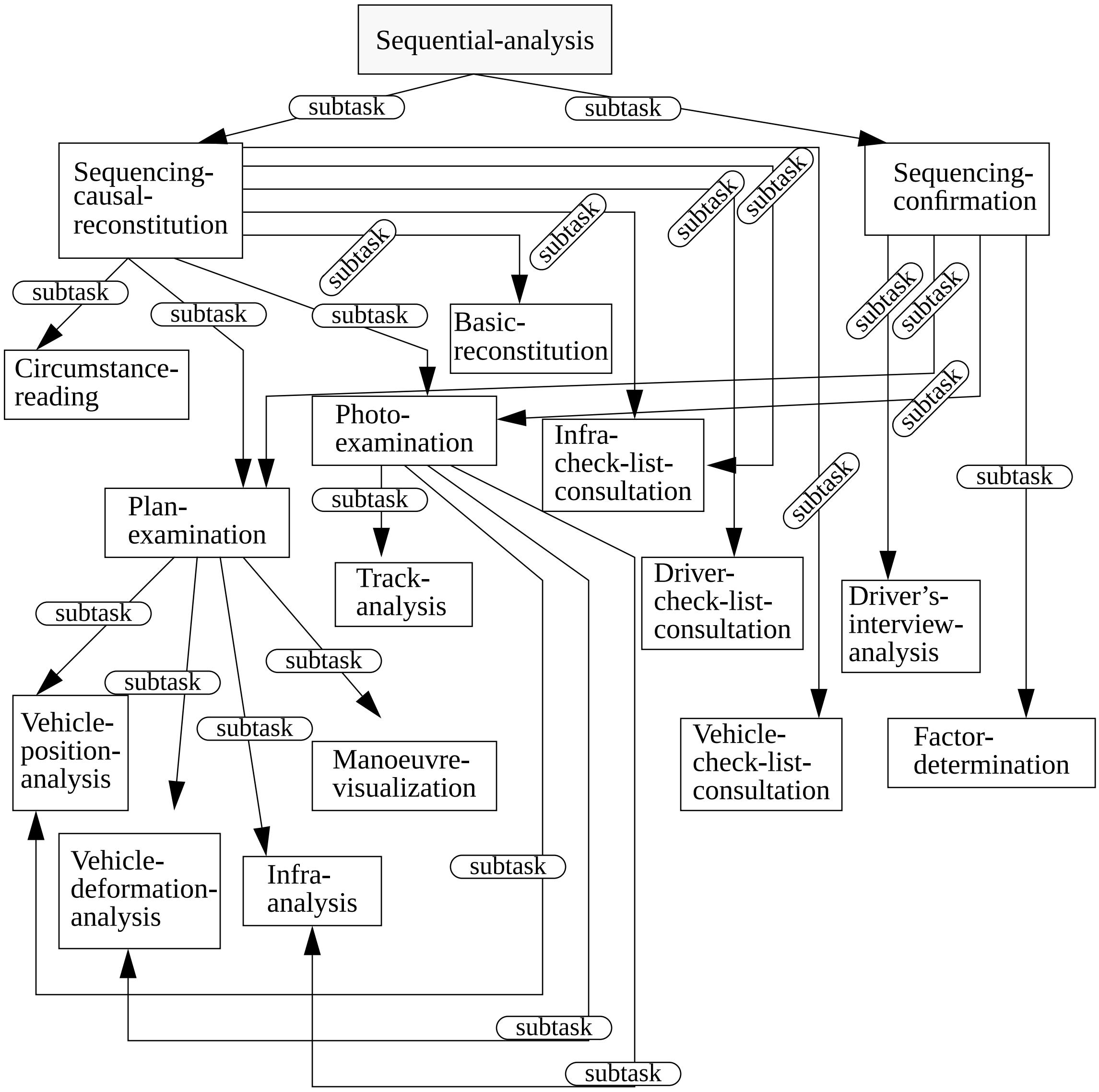
[Cutting-in-situations] → (next) → [Driving-situation-analysis]→ (next) → [Accident-situation-analysis] → (next) → [Emergency-situation-analysis] → (next) → [Solicitation-analysis] → (next) → [Analysis-of-limitations-of-performances-w.r.t.answer-capacities]

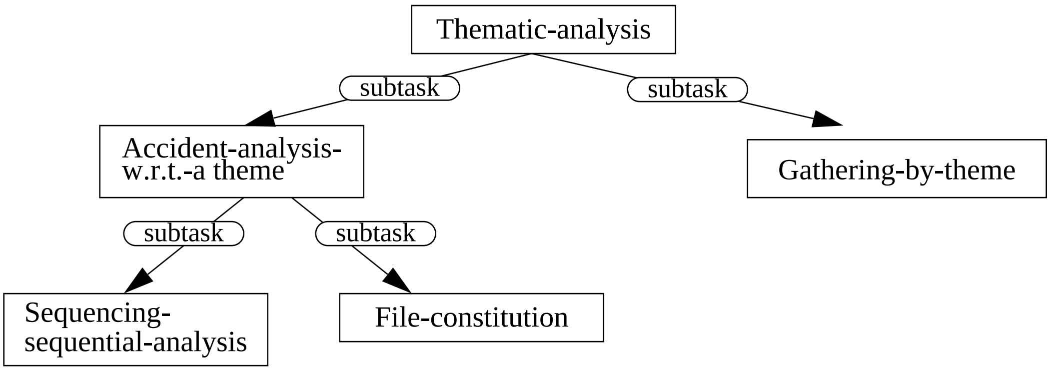
...

For sake of simplicity, in the remaining task models, we will not show graphically the relation-nodes (next) between successive subtasks of a same task.

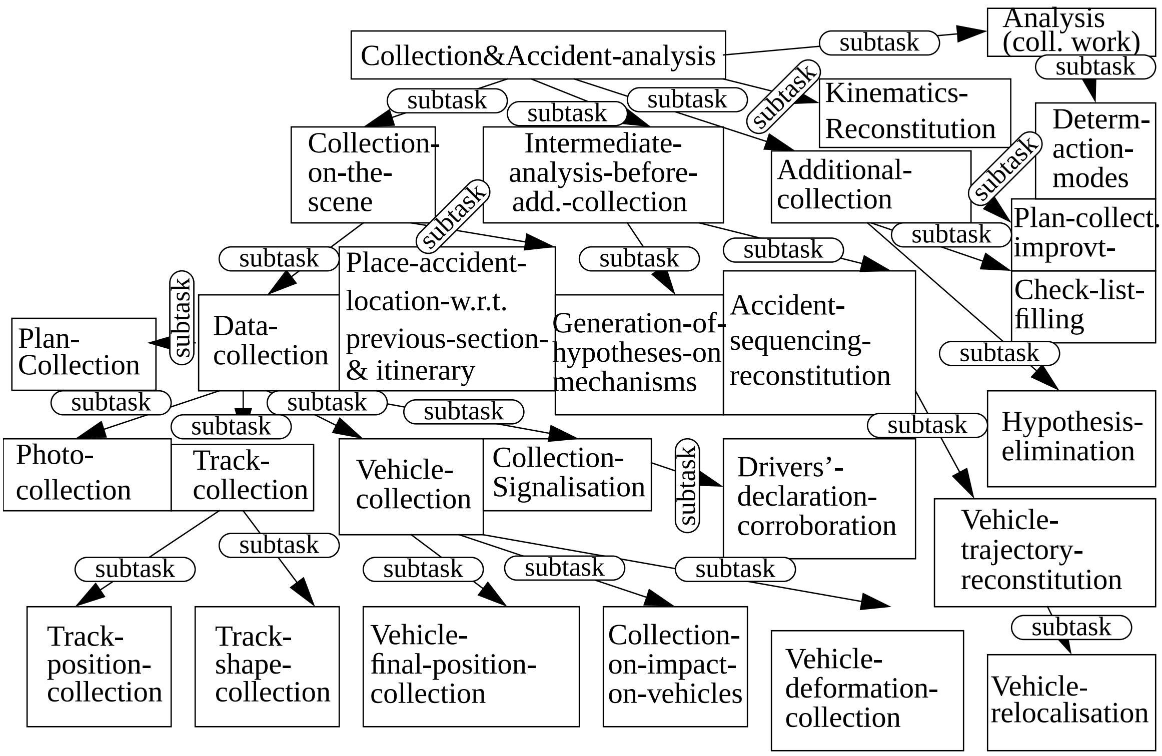
5.2.2 E-infra1's Task Model according to his Interviews




Sequential-analysis
subtask
subtask
Sequencing-causal-reconstitution
Sequencing-confirmation
subtask
subtask
subtask
subtask
subtask
subtask
subtask
subtask
Circumstance-reading
Basic-reconstitution
Photo-examination
Infra-check-list-consultation
subtask
subtask
subtask
subtask
Plan-examination
Track-analysis
Driver-check-list-consultation
Driver's-interview-analysis
subtask
subtask
subtask
subtask
Vehicle-position-analysis
Manoeuvre-visualization
Vehicle-check-list-consultation
Factor-determination
Vehicle-deformation-analysis
Infra-analysis
subtask
subtask
subtask



5.2.3 E-infra2's Task Model according to his Interviews



[Plan-Collection] - { → (exploits) → [Roadsign-position]
→ (exploits) → [Marking]
→ (exploits) → [Vehicle-position]
→ (exploits) → [Track-position]}

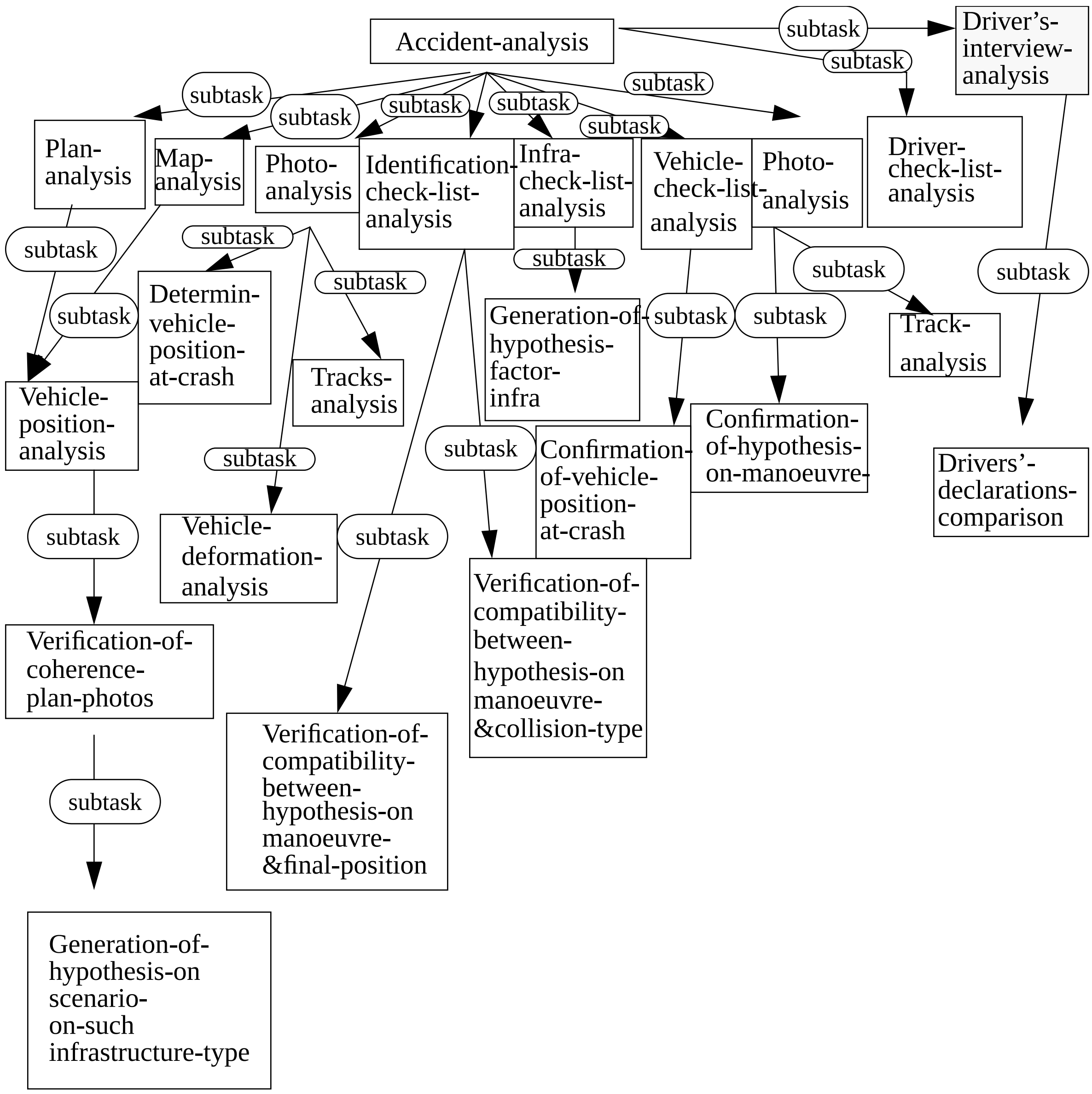
[Place-accident-location] - { → (exploits) → [Crosswise-profile] ← (chrc) ← [Current-section]
→ (exploits) → [Crosswise-profile] ← (chrc) ← [Previous-section]
→ (exploits) → [Priority-conditions]
→ (exploits) → [Homogeneity-w.r.t.previous-section]}

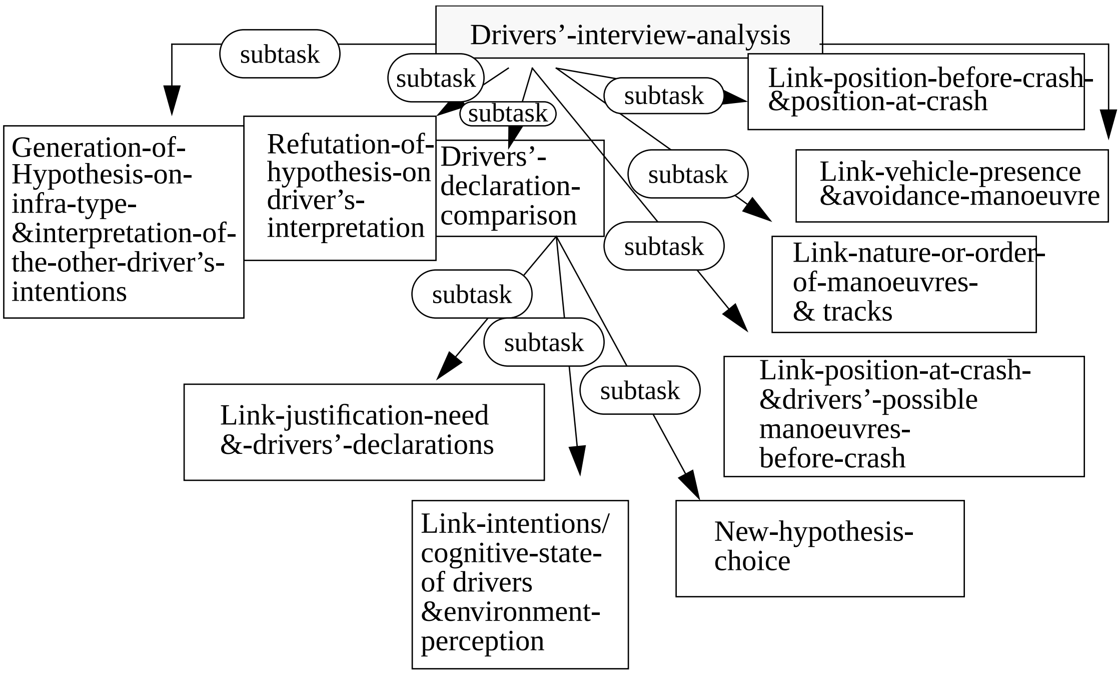
[Drivers'-declaration-corroboration] - { → (exploits) → [Horizontal-roadsign]
→ (exploits) → [Vertical-roadsign]
→ (exploits) → [Marking]
→ (exploits) → [Environment]}

[Trajectory-reconstitution] - { → (exploits) → [Vehicle-position]
→ (exploits) → [Impact-on-vehicles]
→ (exploits) → [Vehicle-deformation]}

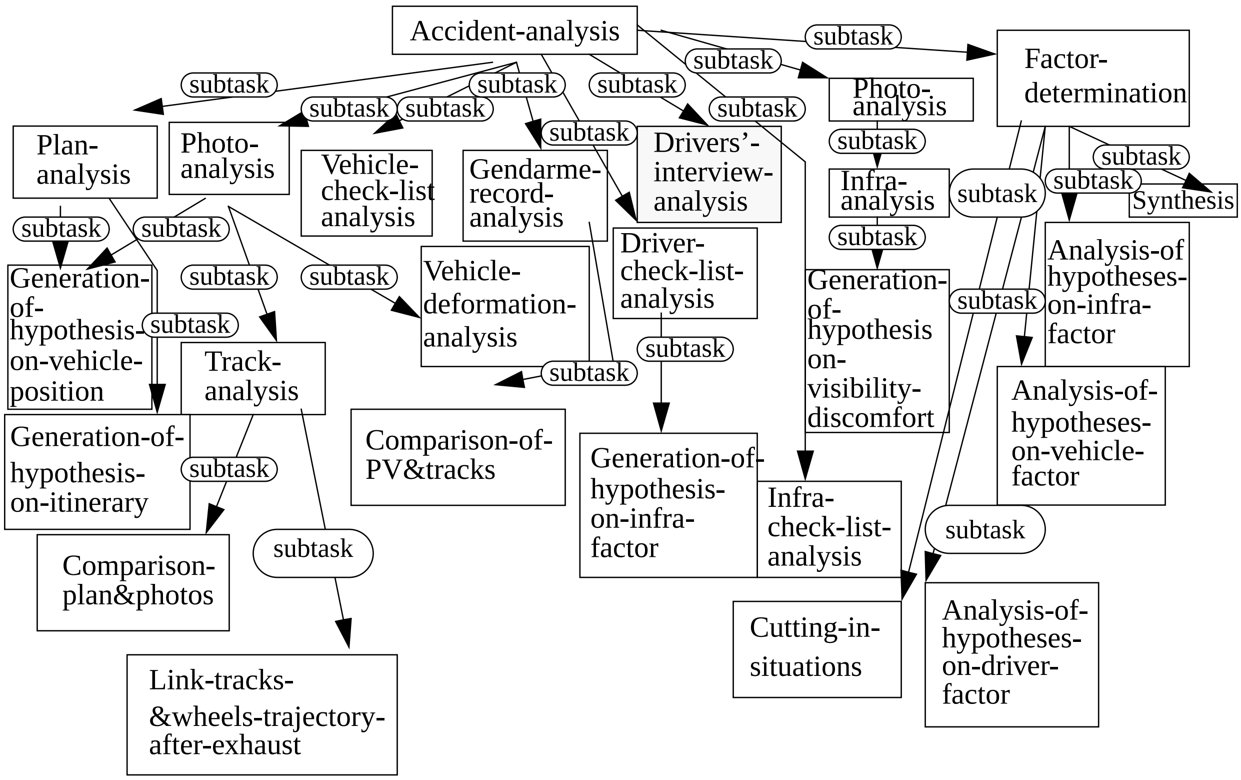
[Kinematics-reconstitution]
- { → (exploits) → [Energy-consumed-after-crash-through-exhausts]
→ (exploits) → [Δv]
→ (exploits) → [space-time-calculation]}

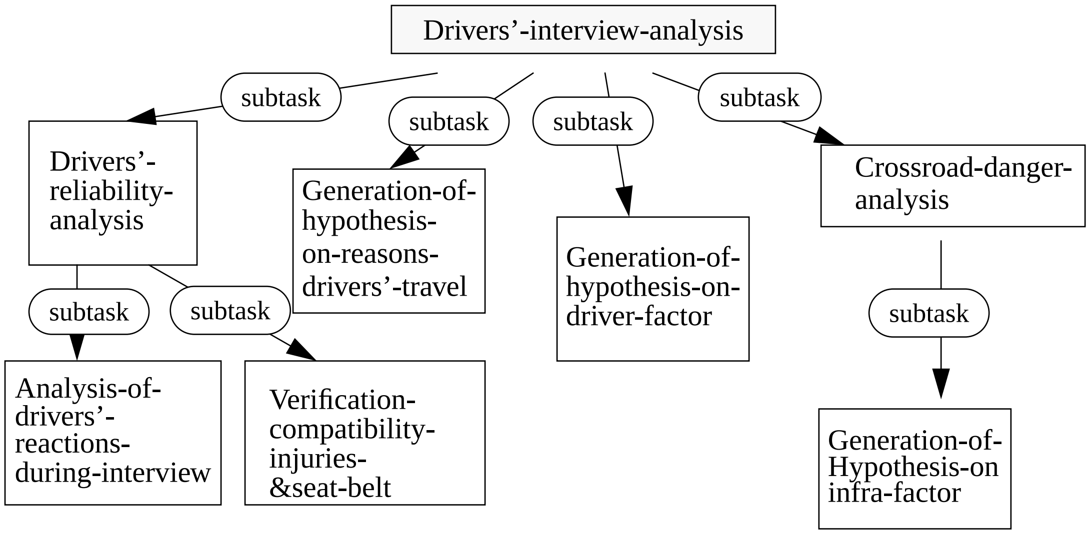
5.2.4 E-psy2's Task Model according to Individual Case Study



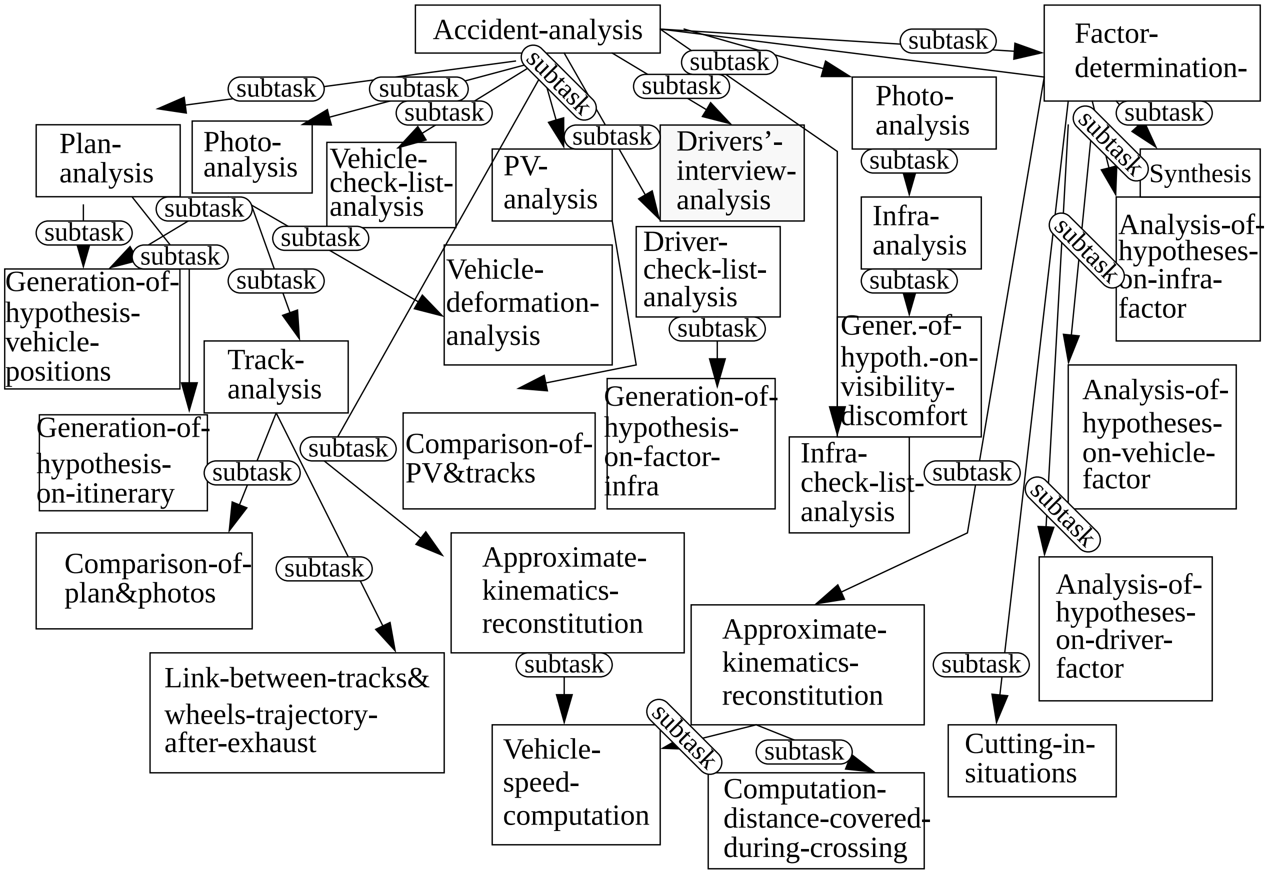

Drivers'-interview-analysis
subtask
subtask
subtask
subtask
subtask
subtask
subtask
subtask
subtask
Generation-of-Hypothesis-on-infra-type-&interpretation-of-the-other-driver's-intentions
Refutation-of-hypothesis-on driver's-interpretation
Drivers'-declaration-comparison
Link-position-before-crash-&position-at-crash
Link-vehicle-presence &avoidance-manoeuvre
Link-nature-or-order-of-manoeuvres-& tracks
Link-position-at-crash-&drivers'-possible manoeuvres-before-crash
Link-justification-need &-drivers'-declarations
Link-intentions/ cognitive-state-of drivers &environment-perception
New-hypothesis-choice

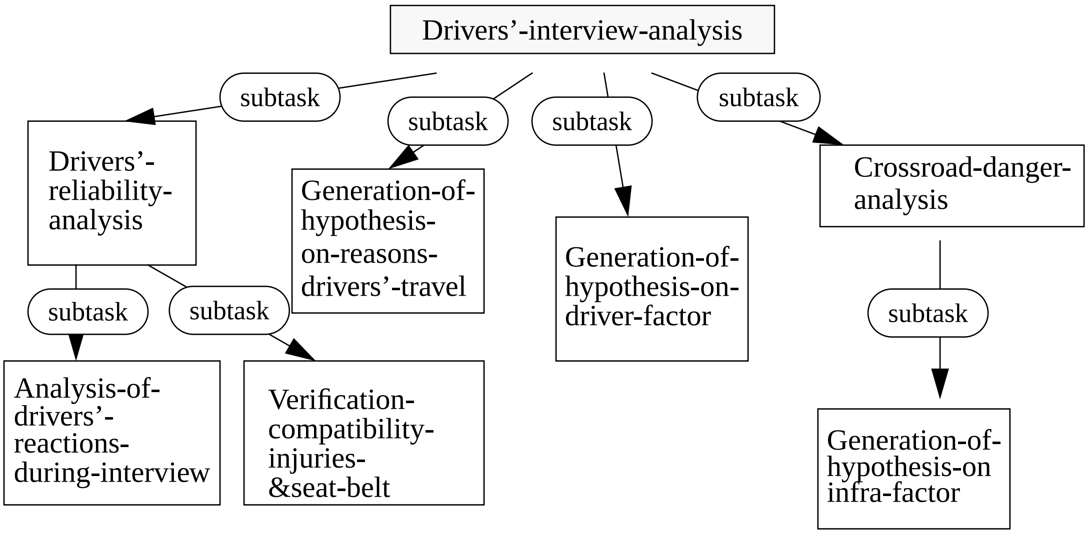
5.2.5 E-psy2's Task Model according to Collective Case Study




Drivers'-interview-analysis
subtask
subtask
subtask
subtask
Drivers'-reliability-analysis
Generation-of-hypothesis-on-reasons-drivers'-travel
Generation-of-hypothesis-on-driver-factor
Crossroad-danger-analysis
subtask
subtask
subtask
Analysis-of-drivers'-reactions-during-interview
Verification-compatibility-injuries-&seat-belt
Generation-of-Hypothesis-on infra-factor

5.2.6 E-infra2's Task Model according to Collective Case Study





5.3 Expertise Rules of the Experts

5.3.1 E-psy2's Expertise Rules

E-psy2's base on the viewpoint " Driver component"

[Accident-time] → **(indicates)** → **[Speed-appreciation]** → (performed-by) → [Driver]

[Driver : *h] → (moving-with) → [Vehicle] → (chrc) → **[Speed]** → **(indicates)** → **[Intentions : {*}]** ← (chrc) ← [Driver : *h]

[Driver : *h] ← (performed-by) ← **[Attention-focalisation]** → **(suggests)** → **[Risk-of-overshadowing-environment-elements]** → (performed-by) → [Driver : *h]

[Experience : *e]
- {← (chrc) ← [Driver : *h]
→ (related-to) → [Driving]
→ (related-to) → [Vehicle-type] ← (chrc) ← [Vehicle] ← (moving-with) ← [Driver : *h]
→ (related-to) → [Infra-type] ← (chrc) ← [Infrastructure] ← (localized) ← [Driver : *h]
→ **(influences)** → **[Available-situation-catalog]** ← (chrc) ← [Driver : *h]
→ **(influences)** → **[Behaviour : {*}]** → (performed-by) → [Driver : *h]}

[Experience : inexperienced-driver]
- {→ **(influences)** → **[Available-situation-catalog : situation-small-catalog]** ← (chrc) ← [Dri-

ver : *h]
→ **(influences)** → **[Behaviour : {risk-of-problem-solving-situation}]** → (performed-by) → [Driver : *h]}

[Experience : too-experienced-driver]
- {→ **(influences)** → **[Available-situation-catalog : situation-big-catalog]** ← (chrc) ← [Driver : *h]
→ **(influences)** → **[Behaviour : {risk-of-information-shallow-taking,**
risk-of-non-congruent-information-rejection,
risk-of-non-fine-research-in-catalog,
risk-of-wrong-situation-identification}]}

[Drug-taking] **-** { → (performed-by) → [Driver : *h]
→ (influences) → [Vigilance] ← (chrc) ← [Driver : *h]
→ (influences) → [Driving] ← (chrc) ← [Driver : *h]}

OR

[Driver : *h] ← (performed-by) ← **[Drug-taking]**
- { → **(influences)** → **[Vigilance]** ← (chrc) ← [Driver : *h]
→ **(influences)** → **[Driving]** ← (chrc) ← [Driver : *h]}

[Behaviour : {*}]
- { ← (chrc) ← [Driver : *h]
→ (suggests) → [Attention-level-w.r.t.driving :{*}] ← (chrc) ← [Driver : *h]}

OR

[Driver : *h] → (chrc) → **[Behaviour : {*}]**→ **(suggests)** → **[Attention-level-w.r.t.driving :{*}]** ← (chrc) ← [Driver : *h]

[Behaviour : {driver-looking-at-infrastructure, driver-listening-to-autoradio}]
- { ← (chrc) ← [Driver : *h]
→ (suggests) → [Attention-level-w.r.t.driving : {distraction, inattention}] ← (chrc) ← [Driver : *h]}

OR

[Driver : *h] → (chrc) → **[Behaviour : {driver-looking-at-infrastructure, driver-listening-to-autoradio}]** → **(suggests)** → **[Attention-level-w.r.t.driving : {distraction, inattention}]** ← (chrc) ← [Driver : *h]}

[Memory-precision-level]

- { ← (chrc) ← [Driver : *h]
→ (suggests) → [Declaration-reliability-level] ← (chrc) ← [Driver : *h]}

OR

[Driver : *h] → (chrc) → **[Memory-precision-level]** → **(suggests)** → **[Declaration-reliability-level]** ← (chrc) ← [Driver : *h]}

[Memory-precision-level : too-precise-memory]
- { ← (chrc) ← [Driver : *h]
→ (suggests) → [Declaration-reliability-level : less-reliable] ← (chrc) ← [Driver : *h]}

OR

[Driver : *h] → (chrc) → **[Memory-precision-level : too-precise-memory]** → **(suggests)** → **[Declaration-reliability-level : less-reliable]** ← (chrc) ← [Driver : *h]}

E-psy2's base on the viewpoint "Infrastructure component"

[Crossroad-type]
- { ← (chrc) ← [Crossroad : *infra] ← (localized) ← [Driver]
→ (influences) → [Priority-mode] ← (chrc) ← [Crossroad : *infra]}

[Traffic-flow-direction]
- { ← (chrc) ← [Crossroad : *infra] ← (localized) ← [Driver]
→ (influences) → [Priority-mode] ← (chrc) ← [Crossroad : *infra]}

OR

[Driver] → (localized) → [Crossroad : *infra] → (chrc) → **[Priority-mode]**
- { ← **(influences)** ← **[Crossroad-type]** ← (chrc) ← [Crossroad : *infra]
← **(influences)** ← **[Traffic-flow-direction]** ← (chrc) ← [Crossroad : *infra]}

E-psy2's base on the viewpoint "Vehicle component"

[Vehicle-model] - { ← (chrc) ← [Vehicle : *v]
→ (suggests) → [Vehicle-features] ← (chrc) ← [Vehicle : *v]}

OR

[Vehicle : *v] → (chrc) → **[Vehicle-model]** → **(suggests)** → **[Vehicle-features]** → (chrc) → [Vehicle : *v]}

[Vehicle-positions-at-crash]
- { ← (chrc) ← [Vehicle : *v1]
→ (may-indicate) → [Previous-trajectory] ← (chrc) ← [Vehicle : *v1]
→ (may-indicate) → [Previous-trajectory] ← (chrc) ← [Vehicle : *v2]
→ (may-indicate) → [Speed-difference] → (between) → [Vehicles : {*v1, *v2}]}

OR

[Vehicles : {*v1, *v2}] → (chrc) → **[Vehicle-crash-positions]**
- { → **(may-indicate)** → **[Previous-trajectory]** ← (chrc) ← [Vehicle : *v1]
→ (may-indicate) → [Previous-trajectory] ← (chrc) ← [Vehicle : *v2]
→ **(may-indicate)** → **[Speed-difference]** → (between) → [Vehicles : {*v1, *v2}]}

[Weight]
- { ← (chrc) ← [Vehicle : *v1]
→ (Topos+) → [Shift-due-to-crash] ← (chrc) ← [Vehicle : *v2]}

OR

[Accident : *a] → (involved-vehicle) → [Vehicle : *v1] → (chrc) → **[Weight]** → **(Topos+)** → **[Shift-due-to-crash] -** { → (agent) → [Vehicle : *v1]
→ (object) → [Vehicle : *v2] ← (involved-vehicle) ← [Accident : *a] }

[Speed-before-crash]
- { ← (chrc) ← [Vehicle : *v1]
→ (Topos+) → [Push-due-to-crash] ← (chrc) ← [Vehicle : *v2]}

OR

[Accident : *a] → (involved-vehicle) → [Vehicle : *v1] → (chrc) → **[Speed-before-crash]** → **(Topos+)** → **[Push-due-to-crash]**
- {→ (agent) → [Vehicle : *v1]
→ (object) → [Vehicle : *v2] ← (involved-vehicle) ← [Accident : *a] }

E-psy2's base on the viewpoint "Environment-Driver Interaction"

[Comfort-degree] **-** { ← (chrc) ← [Infrastructure] ← (localized) ← [Driver : *h]
→ (incites-to) → [Speed-taking] → (performed-by) → [Driver : *h]}

OR

[Driver : *h] → (localized) → [Infrastructure] → (chrc) → **[Comfort-degree]** → **(incites-to)** → **[Speed-taking]** → (performed-by) → [Driver : *h]

[Comfort-degree : comfortable]
- { ← (chrc) ← [Infrastructure] ← (localized) ← [Driver : *h]
→ (incites-to) → [Speed-taking : high] → (performed-by) → [Driver : *h]}

OR

[Driver : *h] → (localized) → [Infrastructure] → (chrc) → **[Comfort-degree : comfortable]** → **(incites-to)** → **[Speed-taking : high]** → (performed-by) → [Driver : *h]

[Environment-features]
- { ← (chrc) ← [Infrastructure] ← (localized) ← [Drivers : {*h1, *h2}]
→ (suggests) → [Mutual-visibility] ← (chrc) ← [Drivers : {*h1, *h2}]}

OR

[Drivers : {*h1, *h2}] → (localized) → [Infrastructure] → (chrc) → **[Environment-features]** → **(suggests)** → **[Mutual-visibility]** ← (chrc) ← [Drivers : {*h1, *h2}]

[Environment] → (chrc) → [Element : *e] ← (in-front-of) ← **[Vegetation]** → **(suggests)** → **[Concealed-visibility]** → (object) → [Element : *e]

[Environment] → (chrc) → [Element : *e] ← (in-front-of) ← **[Vegetation : trees]** → **(suggests)** → **[Concealed-visibility]** → (object) → [Element : *e]

[Proposition : [Driver : *h1]
-{ → (puts-left-indicator)
→ (localized) → [Median-lane] ← (chrc) ← [3-lanes : *infra]
→ (followed-by) → [Driver : *h2]}]
→ **(implies)** →
[Proposition : [Driver : *h2]
- { → (hesitates) → [Intentions : {turn-to-left, overtaking}] ← (chrc) ← [Driver : *h1]]
→ (must-use) → [Element : *e] → (chrc) → [Environment] → (purpose) → [Solve-ambiguity]

[Traffic] - { ← (chrc) ← [Crossroad : *infra] ← (localized) ← [Driver : *h]
→ (influences) → [Strategy] → (chosen-by) → [Driver : *h]→ (purpose) → [Crossing] → (object) → [Crossroad: *infra]
→ (influences) → [Expectations : {*}] ← (chrc) ← [Driver : *h]}

OR

[Driver] → (localized) → [Crossroad : *infra] → (chrc) → **[Traffic]**
- {→ **(influences)** → **[Strategy]** → (chosen-by) → [Driver : *h]→ (purpose) → [Crossing] → (object) → [Crossroad: *infra]
→ **(influences)** → **[Expectations : {*}]** ← (chrc) ← [Driver : *h]}

[Traffic : weak-traffic] **-** { ← (chrc) ← [Crossroad : *infra]← (localized) ← [Driver : *h]
→ (influences) → [Strategy : one-shot-crossing] → (chosen-by) → [Driver : *h]→ (purpose) → [Crossing] → (object) → [Crossroad: *infra]
→ (influences) → [Expectations : {no-other-vehicle}] ← (chrc) ← [Driver : *h]}

OR

[Driver] → (localized) → [Crossroad : *infra] → (chrc) → **[Traffic : weak-traffic]**
- { → **(influences)** → **[Strategy : one-shot-crossing]** → (chosen-by) → [Driver : *h]→ (purpose) → [Crossing] → (object) → [Crossroad: *infra]
→ **(influences)** → **[Expectations : {no-other-vehicle}]** ← (chrc) ← [Driver : *h]}

[Traffic : dense-traffic] **-** { → (chrc) → [Crossroad : *infra]← (localized) ← [Driver : *h]
→ (influences) → [Strategy : crossing-with-stop-in-middle] → (chosen-by) → [Driver : *h]→ (purpose) → [Crossing] → (object) → [Crossroad: *infra]}

OR

[Driver : *h] → (localized) → [Crossroad : *infra] ← (chrc) ← **[Traffic : dense-traffic]** → **(influences)** → **[Strategy : crossing-with-stop-in-middle]** → (chosen-by) → [Driver : *h]→ (purpose) → [Crossing] → (object) → [Crossroad: *infra]}

[Age] **-** { ← (chrc) ← [Driver : *h] → (localized) → [Crossroad: *infra]
→ (influences) → [Strategy] → (chosen-by) → [Driver : *h]→ (purpose) → [Crossing] → (object) → [Crossroad: *infra]}

OR

[Crossroad : *infra] ← (localized) ← [Driver : *h] → (chrc) → **[Age]** → **(influences)** → **[Strategy]** → (chosen-by) → [Driver : *h]→ (purpose) → [Crossing] → (object) → [Crossroad: *infra]

[Age : old] **-** { ← (chrc) ← [Driver : *h] → (localized) → [Crossroad: *infra]
→ (influences) → [Strategy : one-shot-crossing] → (chosen-by) → [Driver : *h]→ (purpose) → [Crossing] → (object) → [Crossroad: *infra]}

OR

[Crossroad : *infra] ← (localized) ← [Driver : *h] → (chrc) → **[Age : old]** → **(influences)** → **[Strategy : one-shot-crossing]** → (chosen-by) → [Driver : *h]→ (purpose) → [Crossing] → (object) → [Crossroad: *infra]

[Infra-type]
- {← (chrc) ← [Infrastructure] ← (previously-localized) ← [Driver : *h]
→ (may-influence) → [Behaviour : {*}] - {← (chrc) ← [Driver : *h]
→ (after-event) → [Infra-type-change]}}

OR

[Driver : *h] → (previously-localized) → [Infrastructure : *infra1] → (chrc) → **[Infra-type]** → **(may-influence)** → **[Behaviour : {*}]**
- {→ (chrc) → [Driver : *h]
→ (after-event) → [Infra-type-change] → (chrc) → [Infrastructure : *infra2] ← (localized) ← [Driver : *h]}

[Infra-type : road-with-many-crossroads]
- {← (chrc) ← [Infrastructure : *infra] ← (previously-localized) ← [Driver : *h]
→ (may-influence) → [Behaviour : {trend-to-speed-up}]
- {← (chrc) ← [Driver : *h]
→ (after-event) → [Infra-type-change : no-more-crossroad] → (chrc) → [Infrastructure : *infra] ← (localized) ← [Driver : *h]}}

OR

[Driver : *h] → (previously-localized) → [Infrastructure : *infra1] → (chrc) → **[Infra-type : road-with-many-crossroads]** → **(may-influence)** → **[Behaviour : {trend-to-speed-up}]**
- { → (chrc) → [Driver : *h]
→ (after-event) → [Infra-type-change] ← (chrc) ← [Infrastructure : *infra2] ← (localized) ← [Driver : *h]}

E-psy2's base on the viewpoint "Vehicle-Environment-Driver Interaction"

[Accident-time]
- { ← (chrc) ← [Accident] → (involved-pers) → [Driver : *h] → (moving-with) → [Vehicle : *v] → (chrc) → [Headlight-state]
→ (influences) → [Visibility] - { → (object) → [Vehicle] → (traffic-direction) → [Direction : in-front]
→ (performed-by) → [Driver : *h]}}

OR

[Headlight-state] ← (chrc) ← [Vehicle : *v1] ← (moving-with) ← [Driver : *h] ← (involved-pers) ← [Accident] → (chrc) → **[Accident-time] → (influences) → [Visibility]**
- { → (object) → [Vehicle : *v2] → (traffic-direction) → [Direction : in-front]
→ (performed-by) → [Driver : *h]}}

[Accident-time : night]
- { ← (chrc) ← [Accident] → (involved-pers) → [Driver : *h] → (moving-with) → [Vehicle : *v] → (chrc) → [Headlight-state : headlights-off]
→ (influences) → [Visibility : no-visibility]
- {→ (object) → [Vehicle] → (traffic-direction) → [Direction : in-front]
→ (performed-by) → [Driver : *h]}}

OR

[Headlight-state : headlights-off] ← (chrc) ← [Vehicle : *v1] ← (moving-with) ← [Driver : *h] ← (involved-pers) ← [Accident] → (chrc) → **[Accident-time: night] → (influences) → [Visibility : no-visibility]**
- { → (object) → [Vehicle : *v2] → (traffic-direction) → [Direction : in-front]
→ (performed-by) → [Driver : *h]}}

E-psy2's base on the viewpoint "Vehicle-Driver Interaction"

[Driving-conditions] ← (chrc) ← [Driver] → (moving-with) → [Vehicle : *v] → (chrc) → **[Vehicle-type] → (suggests) → [Speed]** ← (chrc) ← [Vehicle : *v]

[Driving-conditions : driver-alone] ← (chrc) ← [Driver] → (moving-with) → [Vehicle : *v] → (chrc) → **[Vehicle-type : sport-car] → (suggests) → [Speed : high-speed]** ← (chrc) ← [Vehicle : *v]

[Crash-effects-on-driver] - {← **(influences) ← [Seat-belt-use]**
← **(influences) ← [Collision-type]** ← (chrc) ←[Crash] }

[Crash-effects-on-driver : efficient-protection]
- {← **(influences) ← [Seat-belt-use : seat-belt-fastened]**
← **(influences) ← [Collision-type : frontal-bump]** ← (chrc) ← [Crash] }

[Crash-effects-on-driver : less-efficient-protection]
- {← **(influences)← [Seat-belt-use : seat-belt-fastened]**
← **(influences) ← [Collision-type : lateral-bump]** ← (chrc) ← [Crash] }

[Crash-effects-on-driver : driver-'s-possible-ejection-on-passenger's-seat]
- {← **(influences)** ← **[Seat-belt-use : seat-belt-not-fastened]**
← **(influences)** ← **[Collision-type : lateral-bump**] ← (chrc) ← [Crash] }

E-psy2's base on the viewpoint "Vehicle → Driver's manoeuvres "

[Collision-point] : { → **(suggests)** → **[Manoeuvre]** → (performed-by) → [Driver]
→ **(compatible)** → **[Manoeuvre]** → (performed-by) → [Driver] → (moving-with) → [Vehicle : *v] → (chrc) → **[Starting-position]** }

[Collision-point : collision-on-vehicle-side] → **(suggests)** → **[Turn-to-the-left]** → (performed-by) → [Driver]

[Collision-point : collision-on-vehicle-side] → **(compatible)** → **[One-shot-passage-from-right-lane-to-left-lane]** → (performed-by) → [Driver] → (moving-with) → [Vehicle : *v] → (chrc) → **[Starting-position : right-lane]**

[Driver : *h] → (chrc) → **[Cognitive-state]** → **(suggests)** → **[Driving-behaviour]** ← (chrc) ← [Driver : *h]

[Driver : *h] → (chrc) → **[Cognitive-state : distraction-w.r.t.-driving]** → **(suggests)** → **[Driving-behaviour : unconscious-manoeuvre]** ← (chrc) ← [Driver : *h]

[Obstacle] ← (arriving-to) ← [Vehicle : *v] → (chrc) → **[Speed]** → **(Topos-)** → **[Time]** → **(available-for)** → **[Reaction]** → (performed-by) → [Driver] → (moving-with) → [Vehicle : *v]

[Obstacle] ← (arriving-to) ← [Vehicle : *v] → (chrc) → **[Speed]** → **(Topos+)** → **[Handicap]** → **(related-to)** → **[Avoidance-manoeuvre]** → (performed-by) → [Driver] → (moving-with) → [Vehicle : *v]

E-psy2's base on the viewpoint "Driver's manoeuvres → Vehicle Interaction"

[Vehicle : *v1] ← (moving-with) ← [Driver : *h1] ← (performed-by) ← **[Manoeuvre]** → **(implies)** → **[Manoeuvre-effects]**
-{ → **(upon)** → **[Vehicle : *v1]**
→ **(possible-influence)** → **[Interpretation]** → (performed-by) → [Driver : *h2]}

[Vehicle : *v1] ← (moving-with) ← [Driver : *h1] ← (performed-by) ← **[Changing-down-without-braking]** → **(implies)** → **[Manoeuvre-effects : no-stop-light-lighting-up]**
- { → **(upon)** → **[Vehicle : *v1]**
→ **(possible-influence)** → **[Interpretation]** → (performed-by) → [Driver : *h2]}

E-psy2's base on the viewpoint "Infrastructure - Vehicle Interaction"

[Driver] → (moving-with) → [Vehicle : *v] → (localized) → [Infrastructure] → (chrc) → **[Layout-type] → (incites-to) → [Speed]** ← (chrc) ← [Vehicle : *v]

[Driver] → (moving-with) → [Vehicle : *v] → (localized) → [Infrastructure] ← (chrc) ← **[Layout-type : easy-layout] → (incites-to) → [Speed : high-speed]** ← (chrc) ← [Vehicle : *v]

[Tyre-pressure-unequal-repartition]
: { → **(implies) → [Tyre-grip-influence]**
→ **(implies) → [Efficiency-loss]**
→ **(implies) → [Braking-distance-augmentation]**
→ **(implies) → [Braking-stability-problems]** }

E-psy2's base on the viewpoint "Infrastructure - Vehicle - Driver Interaction"

[Vehicle : *v1] : { → (localized) → [Right-lane]
→ (before) → [Vehicle:*v2] ← (chrc) ← **[Left-indicator] → (incites-to) → [Presumption] → (related-to) → [Overtaking]** → (performed-by) → [Driver : *h2] → (moving-with) → [Vehicle : *v2] }

[No-other-vehicle-before-on-right-lane] ← (situation) ← [Vehicle:*v] → (chrc) → **[Left-indicator] → (incites-to) → [Presumption] → (related-to) → [Turn-to-the-left]** → (performed-by) → [Driver] → (moving-with) → [Vehicle : *v] }

[Driver : *h] → (localized) → [Infrastructure] → (chrc) → **[Configuration-type : like-motorway] - {→ (incites-to) → [Wrong-interpretation-on-road-type]** → (performed-by) → [Driver : *h]
→ **(incites-to) → [Speed : high-speed] }**

[Visibility-distance] → (influences) → [Time] → (available-for) → [Reaction] → (performed-by) → [Driver] → (moving-with) → [Vehicle : *v]

[Vehicle : *v] → (chrc) → **[Speed] → (influences) → [Time] → (available-for) → [Reaction]** → (performed-by) → [Driver] → (moving-with) → [Vehicle : *v]

[Environment] → (chrc) → **[Environment-features : {bush}] → (implies) → [Concealed-visibility]**

[Vehicle:*v] → (chrc) → **[Vehicle-features : {wrongly-set-driving-mirror, not-put-sun-visor}] → (implies) → [Concealed-visibility]** → (for) → [Driver] → (moving-with) → [Vehicle : *v]

[Vehicle:*v2] → (chrc) → **[Distance-and-speed]** ← **(related-to)** ← **[Evaluation]** → **(influences)** → **[Decision]**
- { → (performed-by) → [Driver : *h] → (moving-with) → [Vehicle : *v1]
→ **(purpose)** → **[Crossing]** → **(object)** → **[Crossroad]** ← (localized) ← [Driver : *h1] }

[Vehicle:*v2] → (chrc) → **[Vehicle-type]** → **(influences)** → **[Decision]**
- { → (performed-by) → [Driver : *h] → (moving-with) → [Vehicle : *v1]
→ **(purpose)** → **[Crossing]** → **(object)** → **[Crossroad]** ← (localized) ← [Driver : *h1] }

[Vehicle:*v1] → (chrc) → **[Speeding-up-features]** → **(influences)** → **[Decision]**
- { → (performed-by) → [Driver : *h] → (moving-with) → [Vehicle : *v1]
→ **(purpose)** → **[Crossing]** → **(object)** → **[Crossroad]** ← (localized) ← [Driver : *h1]

[Driver:*h] → (chrc) → **[Driving-type]** → **(influences)** → **[Decision]**
- { → (performed-by) → [Driver : *h] → (moving-with) → [Vehicle : *v]
→ **(purpose)** → **[Crossing]** → **(object)** → **[Crossroad]** ← (localized) ← [Driver : *h]

OR

[Decision]
- { → (performed-by) → [Driver : *h1] → (moving-with) → [Vehicle : *v1]
→ **(purpose)** → **[Crossing]** → **(object)** → **[Crossroad]** ← (localized) ← [Driver : *h1]
← **(influences)** ← **[Evaluation] - {** → **(related-to)** → **[Distance]** → (from) → [Vehicle:*v2]
→ **(related-to)** → **[Speed]** → (chrc) → [Vehicle:*v2]}
← **(influences)** ← **[Vehicle-type]** → (chrc) → [Vehicle:*v2]← **(influences)** ← **[Speeding-up-features]** → (chrc) → [Vehicle:*v1] ← (moving-with) ← [Driver : *h1]
← **(influences)** ← **[Driving-type]** → (chrc) → [Driver : *h1] }

[Vehicle : *v] ← (left-by) ← [Tracks] → (chrc) → **[Track-type]** → **(suggests)** → **[Manoeuvre]** → (performed-by) → [Driver] → (moving-with) → [Vehicle : *v]

[Vehicle : *v] ← (left-by) ← [Tracks] → (chrc) → **[Track-type : straight-tracks]** → **(suggests)** → **[Thorough-braking]** (performed-by) → [Driver] → (moving-with) → [Vehicle : *v]

E-psy2's base on the viewpoint "Accident-location"

[Accident : *a] → **(localized)** → **[Location]** ← **(localized)** ← **[Persons]** → **(suggests)** → **[Seriousness-level]** ← **(chrc)** ← **[Accident : *a]**

[Accident : *a] → (localized) → [Location] ← (localized) ← [Firemen-outside-their-intervention-area] → (suggests) → [Seriousness-level: {many-involved-persons, serious-accident}] → (chrc) →[Accident]

E-psy2's base on the viewpoint "Vehicle -Infrastructure Interaction during the crash"

[Crash : *c] ← (performed-before) ← **[Manoeuvre] → (performed-on) → [Vehicle : *v] ← (chrc) ← [Collision-point] → (suggests) → [Crash-effects-on-vehicle]**
- {← (chrc) ← [Crash : *c]
→ **(relative-to) → [Balance]** ← (chrc) ← [Vehicle : *v]
→ **(relative-to) → [Move-after-crash]** ← (chrc) ← [Vehicle : *v]}

[Crash] ← (performed -before) ← **[Turn-to-the-left] → (performed-on) → [Vehicle : *v] ← (chrc) ← [Collision-point : left-back-side] → (suggests) → [Crash-effects-on-vehicle]**
- { ← (chrc) ← [Crash : *c]
→ **(relative-to) → [Balance : loss-of-balance]** ← (chrc) ← [Vehicle : *v]
→ **(relative-to) → [Move-after-crash: skid]** ← (chrc) ← [Vehicle : *v]}

[Vehicle : *v] ← (left-by) ← **[Tracks : none] → (suggests) → [Behaviour-after-crash : { continue-to-run-normally, not-shift-laterally]** ← (chrc) ← [Vehicle : *v]

[Vehicle : *v] ← (left-by) ← [Tracks] → (chrc) → **[Track-shape] → (suggests) → [Manoeuvre] → (performed-on) → [Vehicle : *v]**

[Vehicle : *v] ← (left-by) ← [Tracks] → (chrc) → **[Track-shape : straight-tracks] → (suggests) → [Thorough-braking] → (performed-on) → [Vehicle : *v]**

[Vehicle : *v] ← (left-by) ← [Tracks] → (chrc) → **[Track-direction] → (suggests) → [Nature-and-order-of-manoeuvres-before-crash]** → (performed-on) → [Vehicle : *v]

[Vehicle : *v] ← (left-by) ← [Tracks] → (chrc) → **[Track-direction : oblique-tracks] → (suggests) → [Nature-and-order-of-manoeuvres-before-crash : {left-turn-of-the-wheels, braking-with-wheel-jamming}]** → (performed-on) → [Vehicle : *v]

[Vehicle : *v] ← (left-by) ← [Braking-tracks] → (chrc) → **[Track-shape] → (may-suggest) → [Manoeuvre] - {** → **(before)** → [**Crash**]
→ (performed-on) → [Vehicle : *v]}

[Vehicle : *v] ← (left-by) ← [Braking-tracks] → (chrc) → **[Track-shape : broken-tracks] → (may-suggest) → [Turn-steering-wheel]**
- { → **(before)** → [**Crash**]
→ (performed-on) → [Vehicle : *v]}

[Vehicle : *v] → (chrc) → **[Move-after-crash : car-gone-to-the-side]** → **(influences)** → **[Track-shape : broken-tracks]** ← (chrc) ← [Braking-tracks] → (left-by) → [Vehicle : *v]

5.3.2 E-infra2's Expertise Rules

E-infra2's base on the viewpoint " Driver component "

[Driver : *h] → (chrc) → **[Behaviour :{*}]** → **(suggests)** → **[Attention-level-w.r.t.-driving : {*}]** ← (chrc) ← [Driver : *h]

[Driver : *h] → (chrc) → **[Behaviour :{driver's-observations-on-infrastructure}]** → **(suggests)** → **[Attention-level-w.r.t.-driving : {distraction, inattention}]** ← (chrc) ← [Driver : *h]

[Driver : *h] → (chrc) → **[Memory-precision-level]** → **(suggests)** → **[Declaration-reliability-level]** ← (chrc) ← [Driver : *h]

[Driver : *h] → (chrc) → **[Memory-precision-level : too-precise-memory]** → **(suggests)** → **[Declaration-reliability-level : less-reliable]** ← (chrc) ← [Driver : *h]

[Driver : *h] ← (performed-with) ←**[Interview-conditions :{*}]** → **(may-indicate)** → **[Declaration-reliability-level]** ← (chrc) ← [Driver : *h]

[Driver : *h] ← (performed-with) ←**[Interview-conditions : {declarations-to-gendarmes, gendarme-record}]** → **(may-indicate)** → **[Declaration-reliability-level : less-reliable]** ← (chrc) ← [Driver : *h]

[Driver : *h] ← (performed-with) ←**[Behaviour-during-interview :{*}]** → **(suggests)** → **[Declaration-reliability-level]** ← (chrc) ← [Driver : *h]

Driver : *h] ← (performed-with) ←**[Behaviour-during-interview :{aggressive, on-the-defensive}]** → **(suggests)** → **[Declaration-reliability-level : less-reliable]** ← (chrc) ← [Driver : *h]

E-infra2's base on the viewpoint " Link between infrastructure and accident type "

[Accident-in-countryside]
- { → (may-suggest) → [Intersection-accident]
→ (may-suggest) → [Vehicle-alone-control-loss-accident-in-straight-line-or-in-bend]
→ (may-suggest) → [Overtaking-accident]
→ (may-suggest) → [Parking-problem]}

E-infra2's base on the viewpoint " Link between accident type and driver"

[Driver : *h] ← (involved-pers) ← **[Control-loss-in-straight-line-accident]**
- {→ (may-suggest) → [State : {Drowsiness, Weariness}] ← (chrc) ← [Driver : *h]

→ **(may-suggest)** → **[Conflictual-situation]** → (due-to) → [Overtaking] → (performed-by) → [Driver : *h]
→ **(may-suggest)** → **[Conflictual-situation]** → (due-to) → [Manoeuvre] → (performed-by) → [Driver : *h2]}

E-infra2's base on the viewpoint " Link between accident type and data collection "

[Overtaking-accident] → **(incites-to)** → **[Data-collection : {search-upstream, work-on-testimonies}]** → (performed-by) → [Expert]

[Vehicle-alone-control-loss-accident] → **(incites-to)** → **[Data-collection : {work-with-involved-persons}]** → (performed-by) → [Expert]

[Overtaking-accident] → **(suggests)** → **[Possible-testimonies]** → (available-for) → [Expert]

[Intersection-accident] → **(suggests)** → **[Possible-testimonies]** → (available-for) → [Expert]

[Pedestrian-accident-in-built-up-area] → **(incites-to)** → **[Analysis-of-what-happened-before-crossing : {where-came-the-pedestrian, where-the-pedestrian-passed-through}]** → (performed-by) → [Expert]

[Vehicle-control-loss-accident] → **(incites-to)** → **[Data-collection : {study-shape-of-the-exit-from-road}]** → (performed-by) → [Expert]

Examples : [**Shape-of-the-exit-from-road : {tangential, crooked}]**

[Vehicle-control-loss-accident-in-bend] → **(incites-to)** → **[Data-collection : {study-the-exit-before-the-bend, search-slowing-down-area, search-if-the-bend-shape-may-generate-high-speed, search-movements-induced-before-passage-on-the-verge}]** → (performed-by) → [Expert]

E-infra2's base on the viewpoint "Vehicle - Driver Interaction"

[Driving-conditions] ← (chrc) ← [Driver] → (moving-with) → [Vehicle : *v] → (chrc) → **[Vehicle-type]** → **(suggests)** → **[Speed]** ← (chrc) ← [Vehicle : *v]

[Driving-conditions : driver-alone] ← (chrc) ← [Driver] → (moving-with) → [Vehicle : *v] → (chrc) → **[Vehicle-type : sport-car]** → **(suggests)** → **[Speed : high-speed]** ← (chrc) ← [Vehicle : *v]

[Crash-effects-on-driver] - {← **(influences)** ← **[Seat-belt-use]**
← **(influences)** ← **[Collision-type]** ← (chrc) ← [Crash] }

[Crash-effects-on-driver : efficient-protection]
- {← (influences) ← [Seat-belt-use : seat-belt-fastened]
← (influences) ← [Collision-type : frontal-bump] ← (chrc) ← [Crash] }

[Crash-effects-on-driver : less-efficient-protection]
- {**← (influences) ← [Seat-belt-use : seat-belt-fastened]**
← (influences) ← [Collision-type : lateral-bump] ← (chrc) ← [Crash] }

[Crash-effects-on-driver : driver-'s-possible-ejection-on-passenger's-seat]
- {← (influences) ← [Seat-belt-use : seat-belt-not-fastened]
← (influences) ← [Collision-type : lateral-bump] ← (chrc) ← [Crash] }

E-infra2's base on the viewpoint " Infrastructure component "

[Choice-to-set-a-giratory-in-infrastructure] → (depends-on) → [Flows-on-the-axes]

[Turn-to-the-left-by-the-right-handside-laying-out] → (implies) → [Danger]

E-infra2's base on the viewpoint "Infrastructure - Driver Interaction"

[Driver : *h] → (localized) → [Infrastructure] → (chrc) → **[Configuration-type] → (influences) → [Behaviour] → (performed-by) → [Driver : *h]**

[Driver : *h] → (localized) → [Infrastructure] → (chrc) → **[Infra-type] → (influences) → [Behaviour-references] → (performed-by) → [Driver : *h]**

Examples : **[Infra-type : {intersection-with-red-light-in-built-up-area, huge-intersection-in-countryside}]**

[Driver : *h] → (localized) → [Environment] → (chrc) → **[Environment-features : {vegetation}] → (may-imply) → [Concealed-visibility]** → (for) → [Driver : *h]

E-infra2's base on the viewpoint "Infrastructure - Vehicle Interaction"

[Roadway : *rw] → (chrc) → [Grip-on-roadway]
- { → **(depends-on) → [Tyre-nature]** ← (chrc) ← [Tyre : *ty] ← (chrc) ← [Wheel : *wh] ← (chrc) ← [Vehicle]
→ (depends-on) → [Grip-coefficient] ← (chrc) ← [Roadway : *rw]
→ (depends-on) → [Load-on-wheel] ← (chrc) ← [Wheel : *wh]
→ (depends-on) → [Water-height] ← (chrc) ← [Roadway : *rw] }

[Vehicle : *v] → (chrc) → [Tyre : *ty] → (chrc) → **[Tyre-position]**

- { → **(influences)** → **[Track-width]** ← **(chrc)** ← **[Lateral-shift-track : *rt]** → (left-by) → [Vehicle : *v]
→ **(influences)** → **[Track-shape]** ← **(chrc)** ← **[Lateral-shift-track : *rt]** }

[Vehicle : *v] → (chrc) → **[Loaded-wheel]** → **(influences)** → **[Track-shape]** ← (chrc) ←[Tracks] → (left-by) → [Vehicle : *v]

[Vehicle : *v] → (chrc) → [Tyre : *ty] → (chrc) → **[Tyre-state]** → **(influences)** → **[Track-shape]** ← (chrc) ← [Tracks] → (left-by) → [Vehicle : *v]

[Vehicle : *v] → (chrc) → [Tyre : *ty] → (chrc) → **[Tyre-state : overinflated-tyre]** → **(influences)** → **[Track-shape : more-reduced-track]** ← (chrc) ← [Tracks] → (left-by) → [Vehicle : *v]

[Situation : [Uni-value-at-APL25] → (<)→ [Number : 12]] → (means) → [Good-infra-conditions-for-braking]

[Situation : [Cross-friction-coefficient] → (>)→ [Number : 60]] → (means) → [Good-infra-conditions-for-braking]

[Speed] → (no-influence) → [Gain-en-devers]

E-infra2's base on the viewpoint "Vehicle - Driver - Environment Interaction"

[Driver : *h] → (moving-with) → [Moving-mode] → (chrc) → **[Moving-mode-type]**
- {→ **(influences)** → **[Perception] - {** → **(object)** → **[Infrastructure]**
→ (performed-by) → [Driver : *h] }
→ **(influences)** → **[Driving-induced-strategy]** → (chosen-by) → [Driver : *h]

Examples of Moving-mode-type : Truck, Light-vehicle, 2-wheeler, Feet

[Obstacle] ← **(from)** ← **[Distance]** → **(influences)** → **[Urgency-manoeuvre]** → (performed-by) → [Driver : *h]

[Obstacle] ← **(from)** ← **[Distance : far]** → **(influences)** → **[Urgency-manoeuvre : {braking, avoidance}]** → (performed-by) → [Driver : *h]

[Obstacle] ← **(from)** ← **[Distance : close]** → **(influences)** → **[Urgency-manoeuvre : {avoidance}]** → (performed-by) → [Driver : *h]

[Straight-tracks] → (compatible) → [Thorough-braking] → (perhaps-followed-by) → [Steering-wheel]

E-infra2's base on the viewpoint "Analysis-after-crash"

[Control-loss] ← (before) ← [Events]
- {← (suggests) ← [Vehicle-control-loss-accident]
← (suggests) ← [Shape-of-the-exit-from-road] }

[Control-loss] ← (before) ← [Events : no-important-event]
- { ← (suggests) ← [Vehicle-control-loss-accident]
← (suggests) ← [Shape-of-the-exit-from-road : tangential] }

[Control-loss] ← (before) ← [Events : movements-performed-far-upstream]
- { ← (suggests) ← [Vehicle-control-loss-accident]
← (suggests) ← [Shape-of-the-exit-from-road : crooked] }

5.4 Models used by the Experts

5.4.1 Agent Model

[Agent] - {→ (chrc) → [Individual-features] - {→ (chrc) → [KADS-expertise-model]
→ (chrc) → [Specialty]
→ (chrc) → [Resources]}
→ (chrc) → [Social-features] - {→ (chrc) → [Cooperation-modes]
→ (chrc) → [Communication-protocols]
→ (chrc) → [Interaction-points]
→ (chrc) → [Conflict-types]
→ (chrc) → [Model-of-other-agents]}

[KADS-expertise-model]] - {→ (chrc) → [Task-level]
→ (chrc) → [Inference-level]
→ (chrc) → [Domain-level]}

5.4.2 Agent Associated to E-psy1

[Psychologist : E-psy1] → (main-task) → [Accident-Collection & Analysis]

[Psychologist : E-psy1] - {→ (KADS-generic-task-model) → [Modelling]
→ (KADS-generic-task-model) → [Diagnosis]}

[Psychologist : E-psy1]
- {→ (domain-model) → [Driver-model]
-{ →(submodel)→ [Model-of-information-processing-by-driver]
→ (submodel) → [Driver's-error-model]}

→ (domain-model) → [Accident-type-model]
→ (domain-model) → [Expertise-rules] → (related-to) → [Hypothesis-generation]
- {→ (related-to) → [Breakdown]
→ (related-to) → [Factor]}}

[Psychologist : E-psy1] - {→ (specialty) → [Psychology]
→ (specialty) → [Driving-support]
→ (specialty) → [Driver's-error-analysis]}

[Psychologist : E-psy1] - { → (resource) → [Plan]
→ (resource) → [Map]
→ (resource) → [Identification-check-list]
→ (resource) → [Infra-check-list]
→ (resource) → [Vehicle-check-list]
→ (resource) → [Driver-check-list]
→ (resource) → [Drivers'-interviews]
→ (resource) → [Tracks]}

[Psychologist : E-psy1] - {→ (input-interaction-point) → [Advices-on-driver's-interview-techniques]
→ (input-interaction-point) → [Driver's-error-typology]
→ (input-interaction-point) → [Driving-support]}

[Psychologist : E-psy1] → (other-agents-model) → [View-on-task]
- {→ (related-to) → [Kinematics-reconstitution]
→ (performed-by) → [Vehicle-engineer]}

5.4.3 Agent Associated to E-psy2 from his Reports and Interviews

[Psychologist : E-psy2] → (main-task) → [Accident-Collection & Analysis]

[Psychologist : E-psy2] - {→ (KADS-generic-task-model) → [Modelling]
→ (KADS-generic-task-model) → [Diagnosis]}

[Psychologist : E-psy2] - {→ (domain-model) → [CVI-model]
→ (domain-model) → [Driver-model]
- { → (submodel) → [Model-of-driver-on-crossroad]
→ (submodel) → [Model-of-driver-having-right-of-way]
→ (submodel) → [Old-driver-model]

→ (submodel) → [GTI-driver-model] }
→ (domain-model) → [Vehicle-model] → (submodel) → [GTI-model]
→ (domain-model) → [Infrastructure-model] → (submodel) → [Crossroad-model]}

[Psychologist : E-psy2] - { → (specialty) → [Psychology]
→ (specialty) → [Crossroad-study]
→ (specialty) → [GTI-driver-study]
→ (specialty) → [Old-driver-study]}

[Psychologist : E-psy2] - { → (resource) → [Plan]
→ (resource) → [Map]
→ (resource) → [Identification-check-list]
→ (resource) → [Infra-check-list]
→ (resource) → [Vehicle-check-list]
→ (resource) → [Driver-check-list]
→ (resource) → [Drivers'-interviews]
→ (resource) → [Tracks]}

[Psychologist : E-psy2] → (possible-cooperation-with) → [Infra-engineer : E-infra3]

[Psychologist : E-psy2]
- {→ (input-interaction-point) → [Advices-on-driver's-interview-techniques]
→ (input-interaction-point) → [Knowledge-on-crossroad-crossing-strategies]
→ (input-interaction-point) → [Knowledge-on-GTI-drivers]
→ (input-interaction-point) → [Knowledge-on-old-drivers]}

[Psychologist : E-psy2]
- {→ (output-interaction-point) → [Need-of-expert]→ (related-to) → [Vehicle-engineer]
→ (output-interaction-point) → [Need-of-expert]→ (related-to) → [Infra-engineer]}

[Psychologist : E-psy2]
- {→ (other-agents-model) → [View-on-task]
- { → (related-to) → [Kinematics-reconstitution]
→ (performed-by) → [Vehicle-engineer]}
→ (other-agents-model) → [View-on-expert] → (related-to) → [Psychologist : E-psy1]
→ (other-agents-model) → [View-on-expert] → (related-to) → [Psychologist : Other-psy]
→ (other-agents-model) → [View-on-expert] → (related-to) → [Vehicle-engineer : E-

veh1]
→ (other-agents-model) → [View-on-expert] → (related-to) → [Vehicle-engineer : E-veh2]
→ (other-agents-model) → [View-on-expert] → (related-to) → [Infra-engineer : E-infra1]
→ (other-agents-model) → [View-on-expert] → (related-to) → [Infra-engineer : E-infra3]}

5.4.4 Agent Associated to E-psy2 from his Individual Case Study

[Psychologist : E-psy2] → (main-task) → [Accident-Analysis]

[Psychologist : E-psy2] - {→ (KADS-generic-task-model) → [Modelling]
→ (KADS-generic-task-model) → [Diagnosis]}

[Psychologist : E-psy2] - {→ (domain-model) → [CVI-model]
→ (domain-model) → [Driver-cognitive-model]
→ (domain-model) → [Infrastructure-model]
→ (domain-model) → [Vehicle-model]
→ (domain-model) → [Expertise-rules] → (related-to) → [Hypothesis-generation] → (from) → [Clues]}

[Psychologist : E-psy2] - { → (specialty) → [Psychology]
→ (specialty) → [Crossroad-study]
→ (specialty) → [GTI-driver-study]
→ (specialty) → [Old-driver-study]}

[Psychologist : E-psy2] - { → (resource) → [Plan]
→ (resource) → [Map]
→ (resource) → [Identification-check-list]
→ (resource) → [Infra-check-list]
→ (resource) → [Vehicle-check-list]
→ (resource) → [Driver-check-list]
→ (resource) → [Drivers'-interviews]
→ (resource) → [Tracks]
→ (resource) → [Photos]}

[Psychologist : E-psy2]
- {→ (input-interaction-point) → [Advices-on-driver's-interview-techniques]
→ (input-interaction-point) → [Knowledge-on-crossroad-crossing-strategies]
→ (output-interaction-point) → [Need-of-expert]
: - {→ (related-to) → [Vehicle-engineer]
→ (purpose) → [Checking-tyre-defect-conse-

quences]} }

[Psychologist : E-psy2] → (other-agents-model) → [View-on-task]
- {→ (related-to) → [Kinematics-re-constitution]
→ (performed-by) → [Vehicle-engineer]}

5.4.5 Specific Agent Associated to E-psy2 from a Collective Case Study

[Psychologist : E-psy2] → (main-task) → [Accident-Analysis]

[Psychologist : E-psy2] → (specific-task) → [Data-collection-quality-analysis]

[Psychologist : E-psy2] - { → (KADS-generic-task-model) → [Modelling]
→ (KADS-generic-task-model) → [Diagnosis]}

[Psychologist : E-psy2]
- {→ (domain-model) → [CVI-model]
→ (domain-model) → [Driver-cognitive-model]
→ (domain-model) → [Infrastructure-model]
- { → (submodel) → [Infrastructure-types]
→ (submodel) → [Infrastructure-structure]
→ (submodel) → [Crossroad-types]
→ (submodel) → [Crossroad-structure]
→ (submodel) → [Crossroad-crossing-strategies]}
→ (domain-model) → [Expertise-rules] → (related-to) → [Hypothesis-generation] - { → (related-to) → [Accident-scenario]
→ (related-to) → [Breakdown]
→ (related-to) → [Factor]}}

[Psychologist : E-psy2] - { → (specialty) → [Psychology]
→ (specialty) → [Crossroad-study]
→ (specialty) → [GTI-driver-study]
→ (specialty) → [Old-driver-study]}

[Psychologist : E-psy2] - { → (resource) → [Plan]
→ (resource) → [Map]
→ (resource) → [Identification-check-list]
→ (resource) → [Infra-check-list]
→ (resource) → [Vehicle-check-list]
→ (resource) → [Driver-check-list]
→ (resource) → [Drivers'-interviews]
→ (resource) → [Tracks]

→ (resource) → [Photos]}

[Psychologist : E-psy2]
- {→ (cooperation-mode) → [Participation-to-collective-work-organization]
→ (cooperation-mode) → [Reinforcement-of-the-other-expert's-hypotheses]
→ (possible-cooperation-with) → [Infra-engineer : E-infra2]
→ (communication-protocol) → [Explanation-explicit-request]
→ (communication-protocol) → [Express-more-on-his-specialty]}

[Psychologist : E-psy2]
- {→ (input-interaction-point) → [Advices-on-driver's-interview-techniques]
→ (input-interaction-point) → [Knowledge-on-crossroad-crossing-strategies]
→ (output-interaction-point) → [Need-of-expert]→ (related-to) → [Vehicle-engineer]}

[Psychologist : E-psy2]
- {→ (other-agents-model) → [View-on-task]
- {→ (related-to) → [Kinematics-reconstitution]
→ (performed-by) → [Vehicle-engineer]}
→ (other-agents-model → [View-on-expert] → (related-to) → [Infra-engineer : E-infra1] → (on) → [Infra-coding]}

5.4.6 Compound Agent, common to E-psy2 and E-infra2, from a Collective Case Study

[Compound-agent : E-psy2 & E-infra2]
- {→ (domain-model) → [CVI-model]
→ (domain-model) → [Crossroad-model] → (submodel) → [Giratory-model]
→ (domain-model) → [Vehicle-model] → (submodel) → [Seat-belt-model]}

[Compound-agent : E-psy2 & E-infra2]
- {→ (KADS-generic-task-model) → [Modelling]
→ (KADS-generic-task-model) → [Diagnosis]}

[Compound-agent : E-psy2 & E-infra2] - { → (specialty) → [Psychology]
→ (specialty) → [Infra-engineering]
→ (partial-specialty) → [Vehicle-engineering]}

[Compound-agent : E-psy2 & E-infra2] - { → (resource) → [Plan]
→ (resource) → [Map]
→ (resource) → [Identification-check-list]
→ (resource) → [Infra-check-list]
→ (resource) → [Vehicle-check-list]
→ (resource) → [Driver-check-list]

→ (resource) → [Drivers'-interviews]
→ (resource) → [Tracks]
→ (resource) → [Photos]}

[Compound-agent : E-psy2 & E-infra2] → (other-agents-model) → [View-on-task]
- { → (related-to) → [Kinematics-reconstitution]
→ (performed-by) → [Vehicle-engineer]}

[Compound-agent : E-psy2 & E-infra2]
- {→ (subagent) → [Psychologist : E-psy2]
→ (subagent) → [Infra-engineer : E-infra2]
→ (organizational-structure) → [Hierarchy : no-hierarchy]
→ (organizational-structure) → [Task-organization : no-task-sharing]
→ (organizational-structure) → [Agreement-for-collective-task-organization]
→ (organizational-structure) → [Real-time-common-reasoning] → (independent-from) → [Specialty]}

5.4.7 Agent Associated to E-veh1, from his Interviews and his Case Study

[Vehicle-engineer : E-veh1] → (main-task) → [Kinematics-reconsitution]

[Vehicle-engineer : E-veh1] → (KADS-generic-task-model) → [Modelling]

[Vehicle-engineer : E-veh1]
- { → (domain-model) → [CVI-model]
→ (domain-model) → [Vehicle-model]
- { → (submodel) → [Mechanical-defect-model]
→ (submodel) → [Kinematics-sequence-model]}
→ (domain-model) → [Track-model]
→ (domain-model) → [Accident-model]
- { → (submodel) → [Accident-type-model]
→ (submodel) → [Accident-scenario-model]}
→ (domain-model) → [Expertise-rules]
- { → (related-to) → [Kinematics-sequence-cutting]
→ (related-to) → [Hypothesis-generation]}}

[Vehicle-engineer : E-veh1] → (specialty) → [Vehicle-engineering]

[Vehicle-engineer : E-veh1] - { → (resource) → [Plan]
→ (resource) → [Map]
→ (resource) → [Identification-check-list]
→ (resource) → [Infra-check-list]
→ (resource) → [Vehicle-check-list]
→ (resource) → [Driver-check-list]

→ (resource) → [Drivers'-interviews]
→ (resource) → [Tracks]
→ (resource) → [Photos]
→ (resource) → [ANAC-2D] → (nature) → [Tool]
→ (resource) → [ANAC-3D] → (nature) → [Tool]}

[Vehicle-engineer : E-veh1] → (input-interaction-point) → [Knowledge-on-kinematics-reconstitution]

[Vehicle-engineer : E-veh1] → (other-agents-model) → [View-on-terminology]
- { → (related-to) → [Scenario]
→ (chrc) → [Infra-engineer : E-infra1]}

5.4.8 Agent Associated to E-veh2, from his Interviews and his Case Study

[Vehicle-engineer : E-veh2] → (main-task) → [Kinematics-reconsitution]

[Vehicle-engineer : E-veh2] → (KADS-generic-task-model) → [Modelling]

[Vehicle-engineer : E-veh2]
- { → (domain-model) → [CVI-model]
→ (domain-model) → [Vehicle-model]
- { → (submodel) → [Mechanical-defect-model]
→(submodel) → [Kinematics-model]→ (submodel) → [Kinematics-sequence-model] }
→ (domain-model) → [Track-model]
→ (domain-model) → [Phase-cutting-model]
→ (domain-model) → [Accident-model] → (submodel) → [Accident-scenario-model]}
→ (domain-model) → [Expertise-rules] → (related-to) → [Hypothesis-generation]}}

[Vehicle-engineer : E-veh2] → (specialty) → [Vehicle-engineering]

[Vehicle-engineer : E-veh2] - { → (resource) → [Plan]
→ (resource) → [Map]
→ (resource) → [Identification-check-list]
→ (resource) → [Infra-check-list]
→ (resource) → [Vehicle-check-list]
→ (resource) → [Driver-check-list]
→ (resource) → [Drivers'-interviews]
→ (resource) → [Tracks]
→ (resource) → [Photos]

→ (resource) → [ANAC] → (nature) → [Tool]}

[Vehicle-engineer : E-veh2] → (input-interaction-point) → [Knowledge-on-kinematics-re-consitution]

[Vehicle-engineer : E-veh2] → (other-agents-model) → [View-on-terminology]
- { → (related-to) → [Scenario]
→ (chrc) → [Infra-engineer : E-infra1]}

5.4.9 Agent Associated to E-infra1 from his Reports, Interviews and Case Studies

[Infra-engineer : E-infra1] → (main-task) → [Accident-Collection & Analysis]

[Infra-engineer : E-infra1] - {→ (KADS-generic-task-model) → [Modelling]
→ (KADS-generic-task-model) → [Diagnosis]}

[Infra-engineer : E-infra1]
- { → (domain-model) → [Accident- model]
- { → (submodel) → [Accident-categories]
→ (submodel) → [Accident-typology] }
→ (domain-model) → [Infrastructure-model]
- { → (submodel) → [Road-typology]
→ (submodel) → [Section-typology] }
→ (domain-model) → [Involved-mode-model]
→ (domain-model) → [Driver-model]
- { → (submodel) → [Driver-profile-model]
→ (submodel) → [Roaduser-model]}
→ (domain-model) → [Vehicle-model]
→ (domain-model) → [Model-of-manoeuvre-origin-of-accident]
→ (domain-model) → [Accident-scenario-model]
→ (domain-model) → [Kinematics-model]
→ (domain-model) → [VHE-model]
→ (domain-model) → [Phase-model]
→ (domain-model) → [Functional-model]
→ (domain-model) → [Expertise-rules]
- {→ (related-to) → [Vehicle]
→ (related-to) → [Human]
→ (related-to) → [Environment]
→(related-to)→[Human-Environment- Interaction]}}

[Infra-engineer : E-infra1] - { → (specialty) → [Infra-engineering]
→ (partial-specialty) → [Vehicle-engineering]}

[Infra-engineer : E-infra1] - { → (resource) → [Plan]

→ (resource) → [Map]
→ (resource) → [Identification-check-list]
→ (resource) → [Infra-check-list]
→ (resource) → [Vehicle-check-list]
→ (resource) → [Driver-check-list]
→ (resource) → [Drivers'-interviews]
→ (resource) → [Tracks]}

[Infra-engineer : E-infra1]

- {→ (input-interaction-point) → [Knowledge-on- infrastructure]

→ (input-interaction-point) → [Knowledge-on-accident-type]

→ (input-interaction-point) → [Knowledge-on-phase-model]

→ (input-interaction-point) → [Knowledge-on-accident-scenarios]}

[Infra-engineer : E-infra1]

- {→ (other-agents-model) → [View-on-task]

- { → (related-to) → [Kinematics-reconstitution]

→ (performed-by) → [Vehicle-engineer]}

→ (other-agents-model) → [View-on-expert] → (related-to) → [Psychologist : E-psy1]

→ (other-agents-model) → [View-on-expert] → (related-to) → [Psychologist]

→ (other-agents-model) → [View-on-expert] → (related-to) → [Infra-investigator]

→ (other-agents-model) → [View-on-expert] → (related-to) → [Infra-engineer : E-infra3]}

5.4.10 Agent Associated to E-infra2 from his Interviews

[Infra-engineer : E-infra2] → (main-task) → [Accident-Collection & Analysis]

[Infra-engineer : E-infra2] - {→ (KADS-generic-task-model) → [Modelling]
→ (KADS-generic-task-model) → [Diagnosis]}

[Infra-engineer : E-infra2]
- {→ (domain-model) → [CVI-model]

→ (domain-model) → [Driver- model] → (submodel) → [Roaduser-model]
→ (domain-model) → [Infrastructure-model]
- { → (submodel) → [Roadway-model]
→ (submodel) → [Infra-design-model] }
→ (domain-model) → [Track- model]
→ (domain-model) → [Vehicle-model]
→ (domain-model) → [Accident-type-model]
→ (domain-model) → [Phase-model]
→ (domain-model) → [Expertise-rules] → (related-to) → [Hypothesis-generation]→ (related-to) → [Accident-type] - { → (related-to) → [Vehicle-type]
→ (related-to) → [Infra-type]}}

[Infra-engineer : E-infra2] - { → (specialty) → [Infra-engineering]
→ (partial-specialty) → [Vehicle-engineering]}

[Infra-engineer : E-infra2] - { → (resource) → [Plan]
→ (resource) → [Map]
→ (resource) → [Identification-check-list]
→ (resource) → [Infra-check-list]
→ (resource) → [Vehicle-check-list]
→ (resource) → [Driver-check-list]
→ (resource) → [Drivers'-interviews]
→ (resource) → [Tracks]
→ (resource) → [Camera]
→ (resource) → [Photos]
→ (resource) → [Measurement-roulette] → (nature) → [Tool]
→ (resource) → [Tampon-encreur] → (nature) → [Tool]}

[Infra-engineer : E-infra2]
- { → (input-interaction-point) → [Knowledge-on- tracks]
→ (input-interaction-point) → [Knowledge-on-roadway]
→ (input-interaction-point) → [Knowledge-on-accident-types]
- { → (related-to) → [Vehicle-type]
→ (related-to) → [Infra-type]}
→ (input-interaction-point) → [Knowledge-on-infra-design] → (purpose) → [Avoid-some-accident-types]
→ (output-interaction-point) → [Need-of-task]→ (related-to) → [Kinematics-reconstitution] → (purpose) → [Speed-factor-control]}

[Infra-engineer : E-infra2]
- {→ (other-agents-model) → [View-on-task]
- { → (related-to) → [Kinematics-reconstitution]

→ (performed-by) → [Vehicle-engineer]}
→ (other-agents-model) → [View-on-expert] → (related-to) → [Psychologist]
→ (other-agents-model) → [View-on-expert] → (related-to) → [Infra-investigator]
→ (other-agents-model) → [View-on-expert] → (related-to) → [Psychologist : E-psy2]
→ (other-agents-model) → [View-on-expert] → (related-to) → [Vehicle-engineer : E-veh1]}

5.4.11Specific Agent Associated to E-infra2 from the Collective Case Study

[Infra-engineer : E-infra2] → (specific-task) → [Approximative-kinematics-reconstitution]

[Infra-engineer : E-infra2] - {→ (KADS-generic-task-model) → [Modelling]
→ (KADS-generic-task-model) → [Diagnosis]}

[Infra-engineer : E-infra2]
- {→ (domain-model) → [CVI-model]
→ (domain-model) → [Driver- model] → (submodel) → [Roaduser-model]
→ (domain-model) → [Infrastructure-model] → (submodel) → [Infra-design-model]
→ (domain-model) → [Track- model]
→ (domain-model) → [Phase-model]
→ (domain-model) → [Expertise-rules] → (related-to) → [Hypothesis-generation]
- {→ (related-to) → [Breakdown]
→ (related-to) → [Factor]}}

[Infra-engineer : E-infra2] - { → (specialty) → [Infra-engineering]
→ (partial-specialty) → [Vehicle-engineering]}

[Infra-engineer : E-infra2] - { → (resource) → [Plan]
→ (resource) → [Map]
→ (resource) → [Identification-check-list]
→ (resource) → [Infra-check-list]
→ (resource) → [Vehicle-check-list]
→ (resource) → [Driver-check-list]
→ (resource) → [Drivers'-interviews]
→ (resource) → [Tracks]
→ (resource) → [Photos]}

[Infra-engineer : E-infra2]
- { → (input-interaction-point) → [Knowledge-on-infra-check-list-coding]
→ (input-interaction-point) → [Knowledge-on-some-vehicle-features]
→ (input-interaction-point) → [Mini-approximative-kinematics-reconstitution]
→ (output-interaction-point) → [Need-of-fine-kinematics-reconstitution]}

[Infra-engineer : E-infra2]

- { → (other-agents-model) → [View-on-kinematics-reconstitution]
→ (other-agents-model) → [View-on-psychologist's-knowledge]}

[Infra-engineer : E-infra2]
- {→ (cooperation-mode) → [Participation-to-collective-work-organization]
→ (cooperation-mode) → [Reinforcement-of-other-expert's-hypotheses]
→ (possible-cooperation-with) → [Psychologist : E-psy2]
→ (communication-protocol) → [Explanation-explicit-request]
→ (communication-protocol) → [Express-more-on-his-specialty]}

[Infra-engineer : E-infra2] → (conflict-type) → [Divergence-on-task-order]→ (related-to) → [Tasks : {Driver-check-list-analysis, Vehicle-check-list-reading, Infra-check-list-rereading]}

5.4.12 Agent Associated to E-infra3 from his Interviews

[Infra-engineer : E-infra3] → (main-task) → [Accident-Collection & Analysis]

[Infra-engineer : E-infra3] - {→ (KADS-generic-task-model) → [Modelling]
→ (KADS-generic-task-model) → [Diagnosis]}

[Infra-engineer : E-infra3]
- { → (domain-model) → [CVI-model]
→ (domain-model) → [Driver- model] → (submodel) → [Roaduser-model]
→ (domain-model) → [Infrastructure-model]
→ (domain-model) → [Track- model]
→ (domain-model) → [Vehicle-model]
→ (domain-model) → [Accident-scenario-model]
→ (domain-model) → [Phase-model]
→ (domain-model) → [Expertise-rules] → (related-to) → [Hypothesis-generation]
- {→ (related-to) → [Infrastructure-model]
→ (related-to) → [Vehicle-model]}}

[Infra-engineer : E-infra3] - { → (specialty) → [Infra-engineering]
→ (partial-specialty) → [Vehicle-engineering]}

[Infra-engineer : E-infra3] - { → (resource) → [Plan]
→ (resource) → [Map]
→ (resource) → [Identification-check-list]
→ (resource) → [Infra-check-list]
→ (resource) → [Vehicle-check-list]
→ (resource) → [Driver-check-list]
→ (resource) → [Drivers'-interviews]
→ (resource) → [Tracks]}

[Infra-engineer : E-infra3]
- {→ (other-agents-model) → [View-on-terminology]
- { → (related-to) → [Scenario]
→ (chrc) → [Infra-engineer : E-infra1]}
→ (other-agents-model) → [View-on-terminology]
- { → (related-to) → [Factor]
→ (chrc) → [Infra-engineer : E-infra2]} }

[Infra-engineer : E-infra3]
- {→ (cooperation-mode) → [Information-exchange] → (performed-with) → [Driver-interviewer]
→ (cooperation-mode) → [Work-realization] → (performed-for) → [Infra-engineer : E-infra1]}

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